Pesticides: Domestic and International Perspectives from Science, Law and Governance
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# THE GOOD, THE BAD AND THE UGLY:
## IMPACTS OF GE CROPS IN THE UNITED STATES

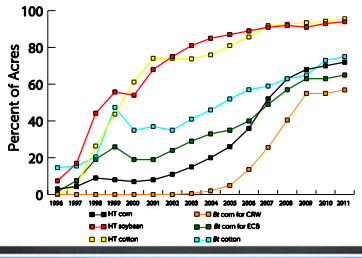
## The GOOD

***Scientific achievements in molecular genetics, biotechnology, and plant breeding***

***Remarkably rapid adoption***

A picture is worth a thousand words…

Percent of National Acres Planted to All Herbicide-Tolerant (HT) and *Bt* Transgenic Crop Varieties , 1996 - 2011 [Combines percent acres planted to single and multiple trait varieties]




***Remarkable commercial success***

Stephen Duke and Michael Owen
on glyphosate, herbicide-tolerant technology

"…the **most rapid adoption of a crop technology** in the history of agriculture."

"…the **most important change in technology** in the ***history of agriculture***."

Stephen O. Duke, 2011. "Comparing Conventional and Biotechnology-based Pest Management," *J. Agricultural and Food Chemistry*, Vol. 59, pages 5793-5798.

Michael D.K. Owen, 2011. "Weed resistance development and management in herbicide-tolerant crops: experiences from the USA," *J. Consumer Protection and Food Safety*, Supplement 1, pages 85-89, doi 10.1007/s00003-011-0679-2

***Roundup Ready (RR) technology largely solved difficult soybean and cotton weed management challenges in the mid-1990s associated with the need to apply multiple, low-dose, often persistent and phytotoxic herbicides***

| 1995 | 2002 |
|---|---|
| 2.7 herbicides/acre (soy) | 1.7 herbicides/acre |
| Tricky timing for optimal control | Wide application window, very forgiving technology |
| Damage from carryover and/or phytotoxicity | Few if any problems with carryover or phytoxicity |

***Huge commercial success. Profits financed the creation of a new, hybrid, multi-billion $$ industry combining assets previously in the separate seed and pesticide industries.***

- Changes in patent and intellectual property law and policy created unprecedented opportunities to expand profit margins
- The pesticide industry, for all intents and purposes, took over the seed industry, in the late 1980s – early 1990s
- DuPont purchased the remaining shares of Pioneer Hi-Bred International for $7.7 billion in March 1999, at an 80% premium over the stock's trading value

***Short-term reduction in herbicide use over the first four years of commercial use***

- Herbicide-tolerant (HT) corn, soybeans and cotton reduced herbicide use by 14.5 million pounds in 1996-1998, or by about 2%
- Rates have risen steadily since, driven by 10% + annual increases in glyphosate rates per crop year
- The 90 million pound increase in herbicide use on HT crops, just from 2010-2011, is six-times larger than the sort-lived reduction in 1996-1998

***Sustained reductions in insecticide use in both corn and cotton, and generally successful mandatory resistance management plans recommended and monitored by mostly Independent university scientists***

| GE Insect Pest Management Trait | Reduction in Insecticides (pounds a.i./acre) |
|---|---|
| *Bt* corn for ECB & other *Lepidoptera* insect control | 0.06 – 0.23 |
| *Bt* corn for corn rootworm and other *Coleoptera* insect control | 0.1 – 0.28 |

## The BAD

***Regional, national and global environmental effects from the dramatic increase in reliance on glyphosate and other herbicides***

- Glyphosate is found in 60 – 100% of rain and air samples tested in Iowa and Mississippi by the U.S. Geological Survey
- Nearly every stream, river, and reservoir in heavily farmed regions contain glyphosate and its degradation products

Feng-Chih Chang, Matt F. Simcik, P.D. Capel, 2011. "Occurrence and Fate of the Herbicide Glyphosate and its Degradate Aminomethylphosphonic Acid in the Atmosphere," *Envir. Toxicology Chem.*, Vol. 30, pages 548-555

***Rapid and unprecedented increases in farmer's seed costs, made possible by changes in intellectual property law and policy, and GE trait technology fees***

| | Corn Seed | Soybean Seed |
|---|---|---|
| 1980s | $60 - $70 / bag | $12.00 / bag |
| 1996 | $77.70 / bag | $14.80 / bag |
| Today | $250 / bag | ~$45.00 - $60.00 / bag |

GE cotton seed costs have risen about ***six-fold*** since 1995. GE seed cost over 30% of expected gross cotton income per acre in 2010, compared to less than 5% of gross income in the pre-GE era.

***Shift in approximately 30% of historic net corn, soybean, and cotton income per acre from farmers to the seed-biotech-pesticide industry***

Historically high crop prices since 2007 have softened the blow of rising costs of GE crop technology

**What will happen when crop prices return closer to historic norms**

***Herbicide-tolerant technology has dramatically accelerated the emergence and spread of resistant weeds***

- Over 14 million acres in the U.S. are now infested with herbicide-resistant weeds
- 22 weeds now resistant to glyphosate, and more than a dozen now pose an economic threat to U.S. farmers
- Some weeds have evolved resistance via two or more mechanisms of resistance!!

David A. Mortensen et al., "Navigating a Critical Juncture for Sustainable Weed Management," *BioScience*, Vol. 62, page 75 and International Survey of Herbicide Resistant Weeds, www.weedscience.org

## *Herbicide-tolerant technology has triggered the emergence and spread of a boatload of multiple-herbicide-resistant weeds…farmers are not "feeling lucky"*

- 108 biotypes of 38 weed species are simultaneously resistant to herbicides in 2 or more families of chemistry
  - 44% of multiple resistant weeds have appeared since 2005
  - Common waterhemp in the U.S. is resistant to more than 20+ currently marketed active ingredients, including glyphosate, ALS, and PPD herbicides

David A. Mortensen et al., "Navigating a Critical Juncture for Sustainable Weed Management," *BioScience*, Vol. 62, page 75

## Major BAD:

## *No quick herbicide-based fixes on the horizon*

**No major new herbicide mode of action has been commercialized in about 20 years****

** Gerwick, "Thirty years of herbicide discovery: surveying the past and contemplating the future," Agrow (Silver Jubilee Edition)

**"…It is very unlikely that new herbicides with new modes of action will be available within ten to 15 years."**

Michael D.K. Owen, 2011. "Weed resistance development and management in herbicide-tolerant crops: experiences from the USA." *J. Consumer Protection and Food Safety*. Supplement 1, pages 85-89, doi \10.1007/s00003-011-0679-2

## *Genetically engineered crops have increased pesticide use in the U.S. by about 400 million pounds over the first 16 years of commercial use*

- HT corn, soybean, and cotton have increase herbicide use an estimated 525 million pounds, compared to what use would likely have been in the absence of HT technology
- *Bt* corn and cotton have reduced insecticide applications by about 125 million pounds since 1996
- First-generation GE crops and traits have increased overall pesticide use by about 400 million pounds (~7%) since 1996

* C. Benbrook et. al., 2012 . forthcoming "Measuring the Impact of GE Crops on Pesticide Use in the United States Using Publicly Available Data".

## *Impacts of Bt corn and cotton on Cry protein endotoxin production*

### *Bt* Corn Traits: Major Events and Products

| Product Name[a] | Event | Year of Launch[b] | Cry Protein | Targets[c] |
|---|---|---|---|---|
| Syngenta Agrisure® CB | *BT* 11 | 1996 | Cry1Ab | Corn Borer |
| Monsanto YieldGard® Corn Borer | MON 810 | 1997 | Cry1Ab | European and Southwestern Corn Borers, Sugarcane Borer and Southern Cornstalk Borer |
| Monsanto YieldGard® Rootworm | MON 863 | 2003 | Cry3Bb1 | Western, Northern, and Mexican Corn Rootworm |
| Monsanto YieldGard VT™ Rootworm | MON 88017 | 2007 | Cry3Bb1 | Western, Northern, and Mexican Corn Rootworm |
| Monsanto Genuity™ VT Double PRO™ | MON 89034 | 2010 | Cry1A.105 Cry2Ab2 | European and Southwestern Corn Borers, Sugarcane Borer, Southern Cornstalk Borer, Corn Earworm, and Fall Armyworm |
| DowAgrosciences Pioneer Hi-Bred Herculex® I | TC1507 | 2003 | Cry1F | Western Bean Cutworm, Corn Borer, Black Cutworm and Fall Armyworm |
| Dow AgroSciences Pioneer Hi-Bred Herculex® RW | DAS 59122-7 | 2006 | Cry34Ab1 Cr35Ab1 | Western Corn Rootworm, Northern Corn Rootworm |
| Monsanto Genuity™SmartStax™, DowAgrosciences SmartStax™ | MON 88017 MON 89034 TC 1507 DAS 59122-7 | 2010 | Cry3Bb1 Cry1A.105 Cry2Ab2 Cry1F Cry34Ab1 Cr35Ab1 | European Corn Borer, Southwestern/Southern Cornstalk Borer, Corn Earworm, Fall Armyworm, Stalk Borers, Sugarcane Borer, Western Bean Cutworm, Western/ Northern/Mexican Corn Rootworm |

[a] Event names for corn from National Corn Growers Association (NCGA) "Know Before You Grow®" Table 1, http://www.ncga.com/know-before-you-grow/; for cotton from Monsanto product descriptions and USEPA 2005. Some events are incorporated into more than one product.

[b]The year that varieties containing each event were first offered for sale was taken from company websites, technology use guides, and farm press articles.

[c]Insect targets for Cry proteins in corn from National Corn Growers Association (NCGA) "Know Before You Grow®" Table 1, http://www.ncga.com/know-before-you-grow/; in cotton from company product descriptions and USEPA 2005.

### *Bt* Corn Expression Levels per Plant Tissue: Major Events and Products

| Product Name | Event | Cry Protein | Plant Stage | Shoot[b] conc. (ug/g dw) | Root conc. (ug/g dw) |
|---|---|---|---|---|---|
| Syngenta Agrisure® CB | *BT* 11 | Cry1Ab | mature | | |
| Monsanto YieldGard® Corn Borer | MON 810 | Cry1Ab | 2 wk post-pollination | | |
| Monsanto YieldGard® Rootworm | MON 863 | Cry3Bb1 | forage, 90 DAP | 130 | 136 |
| Monsanto YieldGard VT™ Rootworm | MON 88017 | Cry3Bb1 | forage, R4-5 | 40 | 50 |
| Monsanto Genuity™ VT Double PRO™ | MON 89034[5] | Cry1A.105<br>Cry2Ab2 | forage, R4-5<br>forage, R4-5 | 18<br>29 | 20<br>16 |
| DowAgrosciences Pioneer Hi-Bred Herculex® I | TC1507 | Cry1F | forage, R4-5 | 7.69 | 5.32 |
| Dow AgroSciences Pioneer Hi-Bred Herculex® RW | DAS 59122-7 | Cry34Ab1<br>Cr35Ab1 | forage, R4-5<br>forage, R4-5 | 168<br>37.1 | 85.4<br>18.3 |
| Monsanto Genuity™SmartStax™, DowAgrosciences SmartStax™ | MON 88017<br>MON 89034<br>TC 1507<br>DAS 59122-7 | Cry3Bb1<br>Cry1A.105<br>Cry2Ab2<br>Cry1F<br>Cry34Ab1<br>Cr35Ab1 | forage, R4-5<br>forage, R4-5<br>forage, R4-5<br>forage, R4-5<br>forage, R4-5<br>forage, R4-5 | 48<br>19<br>29<br>9<br>157<br>33.6 | 65<br>21<br>18<br>5.97<br>84.6<br>18.9 |

### *Bt* Corn Cry Protein Quantities per Land Area: Major Events and Products

| Product Name | Event | Cry Protein | Plant Stage | Plants/acre | Cry/acre (lb/acre) |
|---|---|---|---|---|---|
| Syngenta Agrisure® CB | *BT* 11 | Cry1Ab | mature | 26,500 | **0.252** |
| Monsanto YieldGard® Corn Borer | MON 810 | Cry1Ab | 2 wk post-pollination | 32,000 | **0.183** |
| Monsanto YieldGard® Rootworm | MON 863 | Cry3Bb1 | forage, 90 DAP | 32,000 | **1.732** |
| Monsanto YieldGard VT™ Rootworm | MON 88017 | Cry3Bb1 | forage, R4-5 | 32,000 | **0.551** |
| Monsanto Genuity™ VT Double PRO™ | MON 89034[5] | Cry1A.105<br>Cry2Ab2 | forage, R4-5<br>forage, R4-5 | 32,000<br>32,000 | 0.242<br>0.355<br>**0.597** |
| DowAgrosciences Pioneer Hi-Bred Herculex® I | TC1507 | Cry1F | forage, R4-5 | 32,000 | **0.097** |
| Dow AgroSciences Pioneer Hi-Bred Herculex® RW | DAS 59122-7 | Cry34Ab1<br>Cr35Ab1 | forage, R4-5<br>forage, R4-5 | 32,000<br>32,000 | 2.042<br>0.45<br>**2.492** |
| Monsanto Genuity™SmartStax™, DowAgrosciences SmartStax™ | MON 88017<br>MON 89034<br>TC 1507<br>DAS 59122-7 | Cry3Bb1<br>Cry1A.105<br>Cry2Ab2<br>Cry1F<br>Cry34Ab1<br>Cr35Ab1 | forage, R4-5<br>forage, R4-5<br>forage, R4-5<br>forage, R4-5<br>forage, R4-5<br>forage, R4-5 | 32,000<br>32,000<br>32,000<br>32,000<br>32,000<br>32,000 | 0.672<br>0.256<br>0.36<br>0.112<br>1.918<br>0.412<br>**3.73** |

C. Benbrook, "A Method to Quantify *Bt* Cry Protein Production per Unit Area of Cropland for Commercially Significant *Bt* Corn and Cotton Cultivars," forthcoming.

## *Dramatic increase in* Bt *Cry protein endotoxins in corn-cotton production systems…and nearby soil and aquatic ecosystems*

Every acre planted to *Bt* corn for European corn borer control --
- Reduces *Lepidoptera*–targeted insecticide use by about 0.13 pounds active ingredient per acre, but also…
- Introduces 0.18 to 0.6 pounds of *Bt* Cry proteins per acre

Each acre planted to *Bt* corn for corn rootworm and other soil-borne insects --
- Reduces *Coleoptera*-targeted insecticide use by about 0.21 pounds per acre, but also…
- Introduces between 0.5 and 2.5 pounds of *Bt* Cry proteins per acre

## *On fields planted to Monsanto-Dow AgroSciences* ***SmartStax*** *corn*

- Each plant expresses six different *Bt* Cry proteins, three for ECB/*Lepidoptera*, and three for corn rootworm/*Coleoptera* control
- Total expression of *Bt* proteins is 3.73 pounds per acre – 10-times more than the insecticides displaced (0.34 pounds active ingredient [0.13+0.21 pounds])

## *What about* Bt *crop endotoxin production compared to natural levels of* Bt *in soil*

| Natural *Bt* Soil Microorganisms | *Bt* Cotton | *Bt* Corn |
|---|---|---|
| 0.25 g/ha* | 400 – 1000 g/ha | 2,800 – 4,200 g/ha |

*Bt* cotton produces up to 4,000 times more *Bt* than soil microorganisms, while *Bt* corn produces up to ***16,800 times more***

* Blackwood, C.B., J.S. Buyer, 2004. "Soil Microbial Communities Associated with *Bt* and Non-*Bt* Corn in Three soils," *J. Environmental Quality*, Vol. 33, pages 832-836

## *Clear evidence that* Bt *resistance is emerging in multiple Cornbelt corn rootworm populations*

Why? *Bt* corn for rootworm control produces only a moderate dose….and over 41% of corn farmers did not comply with mandatory *Bt* corn resistance-management provisions in 2010

http://www.businessweek.com/news/2012-02-09/gene-modified-corn-violations-triple-among-u-s-farmers.html

"Insufficient planting of refuges and non-recessive inheritance of resistance may have contributed to resistance. These results suggest that improvements in resistance management and a more integrated approach to the use of *Bt* crops may be necessary."

Aaron J. Grossman et al., 2012. "Field-Evolved Resistance to *Bt* Maize by Western Corn Rootworm," *PlosOne*, Vol. 6, pages 1-7

## *Growing economic costs associated with GE "adventitious presence" (AP) in non-GE, organic, and identity-preserved corn, soybean, and alfalfa crops, grain and seeds*

- Testing costs
- BMPs to prevent pollen flow and seed contamination
- Market disruption and loss of premiums in high-value, GE-sensitive markets

## *Concern along the corn value chain over Syngenta's high-amylase GE corn*

Developed to facilitate conversion of corn to ethanol, but also alters corn functional traits in food manufacturing at a reported 1 in 10,000 contamination level

High amylase corn is …"an accident waiting to happen"

Lynn Clarkson, member, AC 21 Agricultural Biotechnology Advisory Committee

## *First-generation GE corn has undermined 30 years of progress in Integrated Pest Management (IPM), increasing the cost of pest management and enhancing the risk of serious crop losses*

"Within the past 14 years, producers have transitioned from a traditional IPM paradigm (scouting, use of thresholds, and rescue treatments) to that of a less integrated and more insurance-based approach to insect management…"

Michael E. Gray, 2011. "Relevance of Traditional Integrated Pest Management (IPM) Strategies for Commercial Corn Producers in a Transgenic Agroecosystem: A Bygone Era?" *J. Agricultural and Food Chemistry*, Vol. 59, pages 5852-5858

## *Nine reasons contemporary* Bt *corn technology is incompatible with the principles of IPM*

1. Prophylactic treatment not reliant on scouting and thresholds.
2. Inability to target treatments to parts of fields with populations exceeding economic thresholds.
3. Toxin expressed throughout the production season, and not just when insects are most vulnerable or actively feeding.
4. Toxin expressed throughout plant, including tissues that are not fed upon by a target insect.
5. The technology is dependent on single, or closely related toxins, increasing risk of resistance and/or cross-resistance. [continued…]

## *Nine reasons contemporary* Bt *corn technology is incompatible with the principles of IPM*

6. High probability of sub-lethal doses of *Bt* endotoxins in some corn plant tissues during parts of the season, increasing resistance risk.
7. Dependence on a single mode of action.
8. Technology marketed as a complete solution, downplaying the need for other tactics.
9. Presence of *Bt* genes/toxins in most elite corn hybrids denies farmers the choice of a non-*Bt* variety (some 40% of corn producers surveyed in 2009 reported inability to find high-yield potential elite varieties without the *Bt* gene [Grey, 2011. *JAFC*, Vol. 59]).

## *Five factors that would markedly strengthen the argument that* Bt *corn and cotton are compatible with IPM*

1. Fall scouting to determine likely pest pressure in the subsequent season, coupled with adherence to economic thresholds prior to planting of a *Bt* or other transgenic variety.
2. Insect-feeding damage is required to trigger production of the defensive response, i.e. *Bt* toxins in the case of *Bt* corn or cotton. (So, in the event of no or very low pressure, the plant expends no energy on the biosynthesis of *Bt* proteins, nor would any transgenic proteins enter the environment).
3. *Bt* toxin expression is limited to the tissues under attack, and subsides once insect feeding ends. [continued….]

## *Factors strengthening the case that* Bt *corn and cotton are compatible with IPM*

4. The dose of *Bt* toxins delivered to a typical feeding insect meets the EPA Scientific Advisory Committee definition of a "high dose," assuring that over 99% of insects are killed, and thereby minimizing the risk of resistance.
5. Mandatory resistance-management plans are specified by independent university-based entomologists and are adhered to by farmers. When evidence of resistance emerges, resistance-management plan provisions are tightened for the next planting season, sufficient to stop the progression to fully resistant populations.

***All five of the above criteria are now, or will likely become technically feasible within a decade***

## The UGLY

## *The resistance clock is ticking, fast*

"You guys are three years behind us. This is exactly what we looked like three years ago."

Message to Iowa HT corn-soybean farmers from Jason Northsworthy, University of Arkansas weed scientist, after inspecting row-crop fields in central Iowa

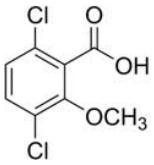
Pam Smith, "New Options for Managing Weeds in Corn," *DTN/Progressive Farmer*, March 21, 2012, access at http://www.dtnprogressivefarmer.com/dtnag/common/link.do;jsessionid=59AC1FEF13F3377B66DF0F0ABAC9825A.agfreejvm1?symbolicName=/free/crops/news/template1&product=/ag/news/production/features&vendorReference=0702DAAF&paneContentId=70115&paneParentId=70104

## Waterhemp resistant to five herbicide modes of action are expected in 2012

Few, if any, viable chemical options will remain

Non-chemical options are costly and require significant system changes -

- Return to rotations
- Use of heavy tillage to bury weed seeds
- Planting of cover crops
- Mechanical cultivation and/or hand weeding


## Industry push to market next-generation 2,4-D, dicamba, and paraquat herbicide-tolerant crops

High-risk gamble, like pouring gasoline on a fire to put it out

Five weed scientists on second-generation HT crops –

"...we expect that synthetic auxin-resistant (2,4-D, dicamba) cultivars will be embraced by growers and planted on rapidly increasing areas in the United States and worldwide over the next 5-10 years."

David A. Mortensen et al., "Navigating a Critical Juncture for Sustainable Weed Management," BioScience, Vol. 62

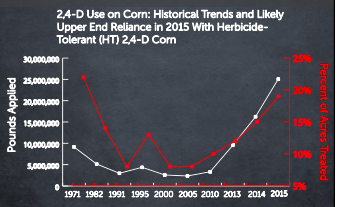
## ...and in response to claims that there are "very few" weed species currently resistant to synthetic auxin herbicides...

"Globally, ***there are 28 species [resistant to 2,4-D and dicamba],*** with 6 resistant to dicamba specifically, 16 to 2,4-D, and at least 2 resistant to both active ingredients."

"...the potential for synthetic auxin-resistant or combined synthetic auxin- and glyphosate-resistant weeds in transgenic cropping systems ***is actually quite high.***" [Emphasis added]

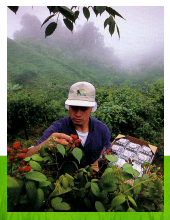
David A. Mortensen et al., "Navigating a Critical Juncture for Sustainable Weed Management," BioScience, Vol. 62

## 73-fold increase in the pounds of 2,4-D applied to corn could occur by 2019, compared to the low-point in 2,4-D corn use in 2002 (4% of acres treated)




## Key parameters in projecting the increase of 2,4-D use on 2,4-D HT corn

- Dicamba-tolerant corn is not approved or marketed
- Adoption peaks at 55% in 2019 (nat'l)
- Average rate of application increase from 0.35 pound in 2010 to 0.6 pounds
- Average number of applications increase from 1.1 in 2010 to 2.3 in 2019
- All acres planted to HT 2,4-D corn varieties WILL be sprayed with 2,4-D



## Economic damage and neighbor-to-neighbor problems caused by the off-target movement of 2,4-D and dicamba applied on second-generation HT crops

"2,4-D drift and volatilization has already become a huge problem on my farm. It has now become an annual occurrence causing significant damage to my farm. Not even the state chemist can determine where this volatilization comes from."

Dave Simmons, Indiana farmer and member of the Save Our Crops Coalition (SOCC)

## *Drift and volatilization of 2,4-D and dicamba*

Even without 2,4-D HT crops, 2,4-D is the #1 cause of crop damage episodes investigated by state departments of agriculture

2,4-D HT crops will vastly worsen problems because of higher rates and applications later in the crop season

"Our company was decimated by an instance of 2,4-D exposure. We continue to try to regain the confidence of our customer base, but it may never be the same. I have joined this coalition to see that no other specialty crop producer has to endure the devastation that our farm has experienced."

Gary Phillips, a Kentucky tree farm and SOCC member )

## *Dealing with the collateral damage from 2,4-D and dicamba applications on second-generation HT crops*

"The acrimony in rural areas will be a major concern as this drift damage occurs. To solve the glyphosate resistant weed problem, we will have to pay a big price and that price will be primarily borne by those who receive little or no benefit from the herbicide application."

Doug Doohan, Associate Professor at Ohio State University

## *Courts will have a very hard time dealing with 2,4-D and dicamba drift and damage cases*

"Our courts and communities are already struggling with the divisive affects of spray drift from genetically altered crops. Right now, this issue is pitting neighbor against neighbor.

"The volatilization issues associated with 2,4-D and dicamba make tracing the source of applications more difficult, and proving liability even for those with devastated crops is costly and uncertain."

Jean Ann Sieler, an attorney representing growers involved in herbicide drift damage litigation in Michigan and Ohio.

SAVE OUR CROPS COALITION

## *Economic damage and neighbor-to-neighbor problems from 2,4-D and dicamba movement*

Quotes from Save Our Crops Coalition, Press Release, April 2, 2012, and website, access at www.saveourcrops.org

## *Environmental and public health problems in the wake of massive increases in synthetic auxin herbicide use*

Multiple studies link 2,4-D applications in the spring to reproductive problems, spontaneous abortions and birth defects 6-9 months later

Farm workers in California employed by operations spraying 2,4-D had dramatically elevated risk of non-Hodgkin's lymphoma (NHL) (odds ratio = 3.8), with female workers facing higher risks

Paul K. Mills, Richard Yang, Deborah Riordan, 2005. "Lymphohematopoietic cancers in the United Farm Workers of America (UFW), 1988-2001," *Cancer Causes and Controls*, Vol. 16, pages 823-830


## *Near-complete failure by government, industry, and farm groups to forestall or prevent herbicide resistance in the face of its virtual certainty*

"Farmers are 'working on the advice largely of industry anymore…Public research is dead; it's decimated.'"

Troy Roush, Indiana farmer and VP of the American Corn Grower's Association


"…the problems associated with GE [genetically engineered] HT [herbicide-tolerant] crops and HR [herbicide-resistant] weeds seem to be largely without resolution attributable, in part, to the general unwillingness of growers to recognize the implications of their management tactics, the unrealistic marketing by the herbicide and seed industries, and the erroneous belief that new technologies and tactics will be available in the short-term future."

Michael D.K. Owen, 2011. "Weed resistance development and management in herbicide-tolerant crops: experiences from the USA." *J. Consumer Protection and Food Safety*, Supplement 1, pages 85-89, doi 10.1007/s00003-011-0679-2


***Industry's near-total success in blocking independent research on GE, pest-management related traits and systems***

GE seed "technology agreements" must be signed when purchasing seed, and all provisions are binding. Most agreements contain language to the effect that –

"This seed is for commercial use by farmers growing crops, and may not be used for any research purpose. Use in any trial or study comparing performance to other corn/soybean/ cotton varieties is prohibited."

***The loss of an independent seed industry dedicated to solving production problems through varietal development***

From the 1950s – 1990s, the major goal of plant breeding research was solving problems confronting farmers, while increasing yield and crop quality

Beginning in late 1990s, the focus has been on commercializing patentable pest-management-related traits

Most universities have essentially ended plant breeding work, except 1-3 crops per state, and only in a handful of states

***Growing evidence of heightened vulnerability of corn and soybeans to a range of plant pathogens, insect, weed, and plant nutrition problems***

Declining plant health triggered by changes in genetics, planting densities, and crop management during the GE crop era

2010 – 11% corn was treated with fungicide (NASS-USDA data)

Less than 1% of corn acres were treated with fungicides in all previous NASS surveys

***Unprecedented escalation in the breadth and toxicity of seed treatments***

Nicotinyl seed treatments critical in protecting farmers investment in *Bt* corn for rootworm (CRW) control

- Lack of a lethal dose of *Bt* toxin in root tissues early in the growing season

Virtually 100% of conventional corn seed treated with a systemic nicotinyl insecticide, plus one to three fungicides

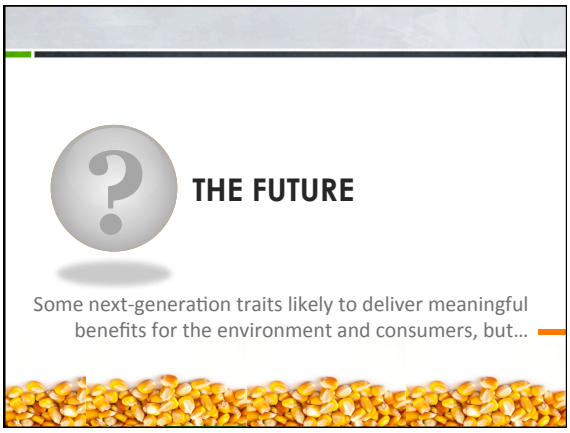
- Nicotinyl seed treatments are likely important missing piece of the honeybee Colony Collapse Disorder (CCD) puzzle

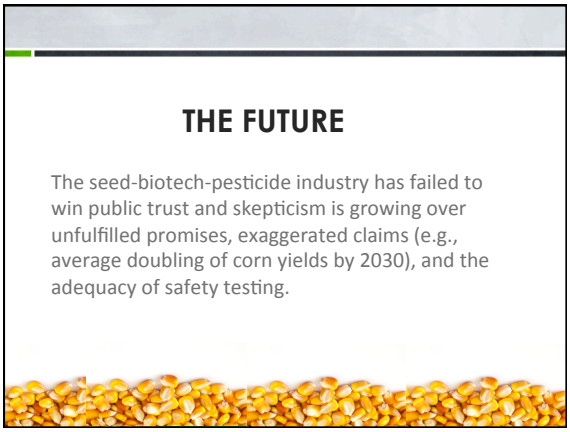
***Reliance on systemic seed treatments lead to novel exposure pathways for a wide range of non-target organisms (bees, livestock, aquatic invertebrates, people)***

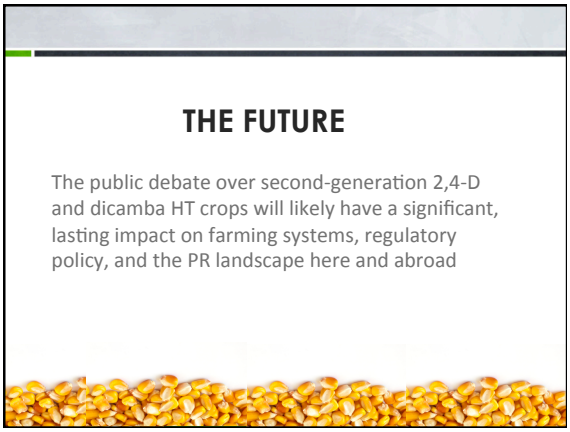
Mixing multiple active ingredients in seed treatments increases the risk of resistance emerging in a variety of soil borne insects

Michael E. Gray, 2011. "Relevance of Traditional Integrated Pest Management (IPM) Strategies for Commercial Corn Producers in a Transgenic Agroecosystem: A Bygone Era?" *J. Agricultural and Food Chemistry*, Vol. 59, pages 5852-5858


THE FUTURE
Next-generation transformation technologies likely to be safer and more predictable


THE FUTURE
Some next-generation traits likely to deliver meaningful benefits for the environment and consumers, but…


THE FUTURE
The seed-biotech-pesticide industry has failed to win public trust and skepticism is growing over unfulfilled promises, exaggerated claims (e.g., average doubling of corn yields by 2030), and the adequacy of safety testing.


THE FUTURE
The public debate over second-generation 2,4-D and dicamba HT crops will likely have a significant, lasting impact on farming systems, regulatory policy, and the PR landscape here and abroad