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## Genetically Modified (GM) Crops and Pesticide Use<sup>1</sup>

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### Worldwide GM Crop Acreage By Trait or Trait Combination<sup>2</sup> (expressed as % of total international GM crop acreage)

Trait(s)	1999	2005	2008
Herbicide tolerance (HT)	71%	71%	63%
Insect resistance (IR)	22%	18%	15%
HT and IR	7%	11%	22%
TOTALS	100%	100%	100%
HT alone or HT/IR	78%	82%	85%

- Herbicide-tolerance lends crops the ability to survive direct application of a broad-spectrum herbicide to kill nearby weeds. HT crops encourage greater and more indiscriminate use of weedkillers, and have higher levels of herbicide residues than normal crops<sup>3</sup>
- Over 5 of every 6 acres of GM crops worldwide (85%) are modified for herbicide-tolerance
- Biotechnology companies have failed to introduce a single GM crop with increased yield potential, enhanced nutrition, drought-tolerance or salt-tolerance. Disease-resistant GM crops are practically non-existent.

<sup>1</sup> This is a revised and updated version of comments delivered at the August 1, 2007 meeting of the USDA's Advisory Committee on Biotechnology and 21st Century Agriculture (AC21).

<sup>2</sup> International Service for Acquisition of Agri-biotech Applications (ISAAA) for respective years. Note that biotechnology and agricultural chemical companies are major funders of ISAAA, and its statistics and analysis particularly with respect to GM crops in developing countries have been criticized for inaccuracies (see, for example, "Who Benefits from GM Crops?" Friends of the Earth International, 2006, at <http://www.foei.org/en/publications/pdfs/gmcrops2006full.pdf>).

<sup>3</sup> For instance, EPA increased the tolerance for glyphosate residues on sugarbeet roots from 0.2 to 10 ppm at the request of Monsanto in 1999, the same year Monsanto gained USDA approval for commercial cultivation of glyphosate-tolerant sugarbeets. See "Glyphosate; Pesticide Tolerance," EPA Final Rule, Federal Register Vol. 64, No. 71, 18360-67, 4/14/99. For other examples, see Center for Food Safety's comments on USDA's Programmatic Environmental Impact Statement on GM crops, p. 60. <http://www.centerforfoodsafety.org/pubs/USDA%20PEIS%20Comment%20Master%20FINAL%20-%209%2011%2007.pdf>.

**The 14 GM Crops Pending Deregulation  
(Commercial Approval) by USDA  
(as of February 5, 2009)**

Trait	No.	Notes
Tolerate 1 herbicide	5	Glyphosate-tolerant alfalfa and creeping bentgrass (golf course grass) (Monsanto) Glyphosate-tolerant (1) and glufosinate-tolerant/insect-resistant (1) cotton (Bayer) ALS inhibitor-tolerant soybeans (BASF)
Tolerates 2 herbicides	1	Dual herbicide-tolerant corn tolerates glyphosate and imidazolinones (a class of ALS inhibitor herbicides) (DuPont-Pioneer)
Insect-resistant alone	2	Corn and cotton (Syngenta)
Virus-resistant	1	New version of old papaya trait (University of Florida)
Enzyme added	1	Corn w/ alpha-amylase enzyme derived from deep sea microorganisms for processing into ethanol. First GE industrial crop. Novel enzyme in corn has characteristics of food allergens, leading top U.S. food allergists to call for more careful evaluation of potential allergy-causing potential of this corn variety. South Africa has refused import clearance based in part on inadequate analysis of potential health impacts from consumption of this corn (Syngenta)
Sterile pollen, fertility altered	2	Corn with sterile pollen (DuPont-Pioneer); freeze-tolerant eucalyptus tree with altered fertility (ArborGen)
Oil alteration	1	High oleic acid soy for processing (DuPont-Pioneer)
Color alteration	1	Carnation (Florigene)

Source: USDA Petitions for Nonregulated Status Pending, February 5, 2009, at: [http://www.aphis.usda.gov/brs/not\\_reg.html](http://www.aphis.usda.gov/brs/not_reg.html) (last accessed February 9, 2009).

- Herbicide-tolerant crops are not only dominant now. They represent the near- and longer-term future of biotech agriculture
- Nearly one-half (6 of 14) of near-future GM crops are herbicide-tolerant; four are tolerant to glyphosate
- One of the six HT crops is modified for tolerance to two herbicides (glyphosate and ALS inhibitors) rather than one, a novel development driven by the dramatic increase in glyphosate-resistant weeds. Dual HT soybeans have already been approved. BASF's ALS inhibitor-tolerant soybeans will likely be crossed for glyphosate-tolerance as well
- In the U.S., the vast majority (>95%) of GM HT crops are glyphosate-tolerant (Roundup Ready)<sup>4</sup>
- Cultivation of Roundup Ready soybeans, cotton and corn is associated with:
  - Large and accelerating increases in the use of glyphosate (see Appendix 1)
  - An epidemic of weeds with resistance to glyphosate (see footnote 3, pp. 11-19)
  - Constant or rising use of older, more toxic, herbicides such as 2,4-D and atrazine (often in combination with glyphosate), to control resistant weeds (Appendix 2)
- The longer-term future of GM crops is also dominated by herbicide-tolerance. As of 2007, over one-third of GM crop field trials involved HT crops; these field trials encompass 18 plant species and tolerance to one or more of 8 different herbicides (see footnote 3, p. 9).

<sup>4</sup> Freese, B. (2007). "Cotton Concentration Report: An Assessment of Monsanto's Proposed Acquisition of Delta and Pine Land," February 2007, International Center for Technology Assessment/Center for Food Safety, Section 3.6.2. [http://www.centerforfoodsafety.org/pubs/CFS-CTA%20Monsanto-DPL%20Merger%20Report%20Public%20Release%20-%20Final%20\\_2\\_.pdf](http://www.centerforfoodsafety.org/pubs/CFS-CTA%20Monsanto-DPL%20Merger%20Report%20Public%20Release%20-%20Final%20_2_.pdf)

## GM Crops Increase Pesticide Use

- Pesticides are chemicals designed to kill pests, whether weeds (herbicides), insects (insecticides) or other pests such as fungi. According to the most comprehensive, independent analysis of the subject, based on exhaustive analysis of USDA data, GM crops increased pesticide use in the U.S. by 122 million pounds from 1996-2004<sup>5</sup>

+ Herbicide-tolerant:	+ 138 million lbs. more herbicides
+ <u>Insect-resistant:</u>	- 16 million lbs. less insecticides
+ NET:	+ 122 million lbs. more pesticides

## The Myth of Reduced Pesticide Use

- Selective reference to and illegitimate extrapolation from the pesticide use impacts of GM crops in the early years of adoption, before herbicide-resistant weeds led to steadily increasing herbicide use

+ 1996 – 1998:	- 20.6 million lbs
+ <u>1999 – 2004:</u>	+ 143.1 million lbs
+ 1996 – 2004:	+ 122.5 million lbs

- Pesticide use reductions from Bt corn sometimes greatly exaggerated by assuming all current Bt corn growers would use insecticides to control European corn borer (ECB) if they switched back to conventional corn. In fact, only 5.2% of corn acreage was sprayed for ECB prior to availability of Bt corn. According to the National Academy of Sciences:

“... the European corn borer, which is the major target of transgenic Bt field corn, has not commonly been controlled with insecticides. A survey of the literature (Gianessi and Carpenter 1999) indicates that across the corn belt only 5.2% of the acreage is sprayed annually for corn borers and in Iowa only 2.6%. Some of the reasons for the lack of chemical control are that the perceived yield loss has always been considered small (estimated at about 4%), the cost of pesticides is high relative to the crop's value, and typical insecticides have not been very efficient at killing the pest after it bores into the plant.”<sup>6</sup>

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<sup>5</sup> Benbrook, C. (2004). “Genetically Engineered Crops and Pesticide Use in the United States: The First Nine Years,” Technical Paper No. 7, October 2004, available at: <http://www.biotechinfo.net/technicalpaper7.html>. Dr. Benbrook is the former chair of the Board on Agriculture of the National Academy of Sciences.

<sup>6</sup> “Genetically Modified Pest-Protected Plants: Science and Regulation,” Board on Agriculture and Natural Resources, National Research Council, National Academy of Sciences, 2000, Section 3.1.2. <http://books.nap.edu/catalog/9795.html>.

## Herbicide-Tolerant Crops Increase Pesticide Use

- **USDA data show clearly that glyphosate use on soybeans, cotton and corn in the U.S. has increased 15-fold (from 7.9 million lbs. to 119.1 million lbs.) from 1994 to 2005.** This dramatic increase in glyphosate use has been driven by the rapid adoption of Roundup Ready versions of these crops, which are engineered for use with glyphosate (brand name: Roundup). Roundup Ready (RR) crops were introduced by Monsanto in 1996 (RR soybeans), 1997 (RR cotton and canola) and 1998 (RR corn). See Appendix 1.
- Increasing glyphosate use is also being driven by a growing epidemic of weeds that have become partially resistant to the chemical. Populations of nine different weed species have been confirmed as glyphosate-resistant in 20 states. Farmers apply heavier doses of glyphosate to kill resistant weeds, which now infest up to 5.4 million acres of U.S. cropland. For instance, **USDA data show that glyphosate use on soybeans has increased from 0.52 lbs./acre/year in 1994 to 1.33 lbs./acre/year in 2006, a more than 2.5-fold increase.**
- Another strategy to control resistant weeds is to apply other herbicides in addition to or in combination with glyphosate. **Appendix 2 documents constant or increasing use of other leading soybean and corn herbicides.** For instance:
  - Overall use of 2,4-D on soybeans increased by more than 2.6-fold from 2002 to 2006. 2,4-D is the second most heavily used soybean herbicide (after glyphosate)
  - Total usage of atrazine on corn increased by 12% from 2002 to 2005, even as glyphosate use on corn increased 5-fold. Atrazine is the most heavily used herbicide on corn.
  - Combined use of the top four corn herbicides increased by 5% from 2002 to 2005.
- **The intensity of overall herbicide use on soybeans, corn and cotton (lbs./acre) has also increased in tandem with rising adoption of Roundup Ready versions of these crops.**
  - Total herbicide use per acre on soybeans and cotton began rising in 2002, after a period of declining herbicide intensity on these crops (Appendix 3).
  - Adoption of Roundup Ready soybeans is clearly correlated with substantially increased use of herbicides, from 0.97 lbs./acre in 2001 to 1.42 lbs./acre in 2006 (Appendix 4).
  - Adoption of herbicide-tolerant cotton is also correlated with increased herbicide intensity: from 1.66 lbs/acre in 2001 to 2.56 lbs/acre in 2007 (Appendix 5).
  - Adoption of herbicide-tolerant corn has lagged behind that of RR soybeans and herbicide-tolerant cotton. However, herbicide intensity has begun to rise here as well, from 1.87 lbs/acre in 2002 to 2.07 lbs/acre in 2005 (Appendix 6).



## Appendix 1: Adoption of Herbicide-Tolerant GM Crops vs. Quantity of Glyphosate Applied in the U.S.

Year	Soybeans		Corn		Cotton		Soybeans, corn, cotton	Notes
	Glyphosate applied <sup>1</sup>	% = HT <sup>2</sup>	Glyphosate applied <sup>1</sup>	% = HT <sup>2</sup>	Glyphosate applied <sup>1</sup>	% = HT		
1994	4,896,000	0%	2,248,000	0%	789,189	0%	<b>7,933,189</b>	The first HT crop, Roundup Ready soybeans, were introduced in 1995.
2002	67,413,000	75%	5,088,000	11%	n.a.	74% <sup>3</sup>	n.a.	
2003	n.a.	81%	13,696,000	15%	14,817,000		n.a.	
2005	75,743,000	87%	26,304,000	26%	17,024,000		<b>119,071,000</b>	More than 15-fold increase in glyphosate use on soybeans, corn and cotton from 1994 to 2005.
2006	96,725,000	89%	n.a.	36%	n.a.	86% <sup>4</sup>	n.a.	More than 19-fold increase in glyphosate use on soybeans, the most widely planted Roundup Ready crop, from 1994 to 2006.
2007	n.a.	91%	n.a.	52%	18,572,000	92% <sup>5</sup>	n.a.	

<sup>1</sup> Pounds of active ingredient. Source for all crops: “Agricultural Chemical Usage: Field Crops Summary,” USDA National Agricultural Statistics Service, for the respective years. Accessible from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560>. The figures represent sum of all versions of glyphosate, including sulfosate. USDA pesticide usage figures cover only a certain percentage of the nationwide acreage planted to the given crop, a percentage which varies from year to year. In order to obtain the best estimate of nationwide use, we have corrected by dividing total reported glyphosate use by the percentage of the nationwide crop acreage for which pesticide usage data was reported. n.a. = not available, note that USDA does not report pesticide usage for all crops in all years.

<sup>2</sup> Percentage of overall crop acreage planted to herbicide-tolerant varieties. From USDA’s Economic Research Service (ERS), see: <http://www.ers.usda.gov/Data/BiotechCrops/alltables.xls>. Figures are the sum of percentages listed for “herbicide-tolerant only” and “stacked gene varieties.” As defined by ERS, stacked gene varieties always contain an HT trait. All HT soybeans are Roundup Ready. In 2006, 96% of HT cotton was Roundup Ready, 4% was tolerant to glufosinate (LibertyLink). Most HT corn is Roundup Ready; a small but unknown percentage is tolerant to glufosinate (LibertyLink).

<sup>3</sup> May, O.L., F.M. Bourland and R.L. Nichols (2003). “Challenges in Testing Transgenic and Nontransgenic Cotton Cultivars,” *Crop Science* 43: 1594-1601. <http://crop.scijournals.org/cgi/reprint/43/5/1594.pdf>. Figure calculated by adding all HT varieties in Table 1. Based on USDA AMS data, see next footnote.

<sup>4</sup> From USDA’s Agricultural Marketing Service (AMS), which has more reliable statistics on cotton than USDA’s ERS. See: “Cotton Varieties Planted: 2006 Crop,” USDA AMS. Figure calculated by adding percentages of all HT varieties (those with designations R, RR = Roundup Ready or RF = Roundup Ready Flex and LL for LibertyLink). Note that most HT cotton is Roundup Ready (Flex); LL cotton varieties comprised only 3-4% of US cotton in 2006.

<sup>5</sup> From “Cotton Varieties Planted: 2007 Crop,” USDA AMS, at: <http://www.ams.usda.gov/mnreports/cnavar.pdf>.

## Appendix 2: Usage of Leading Herbicides Other Than Glyphosate on Corn and Soy in the U.S.: 2002 to 2006

Crop	Soy		Corn			Notes	
	Active ingredient	2,4-D <sup>1</sup> (lbs.)	Atrazine <sup>2</sup> (lbs.)	Acetachlor (lbs.)	Metalachlor/ S-metalachlor (lbs.)		Top 4 corn herbicides (lbs.)
2002		1,389,000	55,018,000	34,702,000	25,875,000	115,595,000	
2003		n.a.	60,480,000	39,203,000	27,535,000	127,218,000	
2005		1,729,000	61,710,000	32,045,000	27,511,000	121,266,000	From 2002 to 2005, atrazine use on corn increased by 12%. Use of the top four corn herbicides increased 4.9%. The 5-fold increase in glyphosate use on corn over the same time span (see Table 1) has clearly not displaced any of the leading corn herbicides.
2006		3,673,000	n.a.	n.a.	n.a.	n.a.	Use of 2,4-D on soy rose by more than 2.6-fold from 2002 to 2006. Over the same period, glyphosate use on soy rose 43% (see Table 1). Glyphosate is clearly not displacing use of 2,4-D.

Figures = pounds of active ingredient. Source: "Agricultural Chemical Usage: Field Crops Summary," USDA National Agricultural Statistics Service for the respective years. Accessible from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560>. USDA pesticide usage figures cover only a certain percentage of the nationwide acreage planted to the given crop, a percentage which varies from year to year. In order to obtain the best estimate of nationwide use, we have corrected by dividing total reported use of the respective herbicide by the percentage of the nationwide crop acreage for which pesticide usage data was reported. n.a. = not available, note that USDA does not report pesticide usage for all crops in all years.

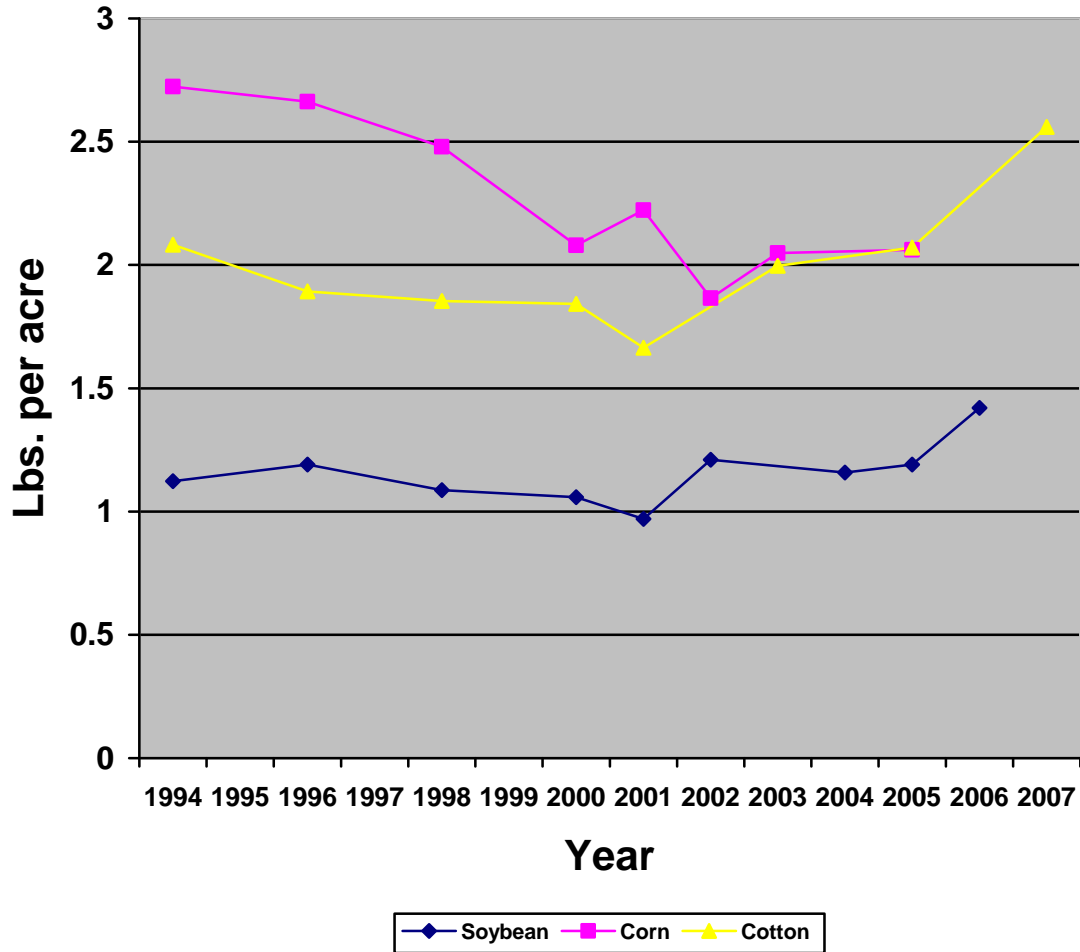
<sup>1</sup> 2,4-D, the second-most heavily used herbicide on soybeans (after glyphosate), is a phenoxy herbicide that formed part of the Vietnam War defoliant Agent Orange. 2,4-D has been associated with a number of adverse health impacts on agricultural workers who apply it: increased risk of cancer, particularly non-Hodgkin's lymphoma, and increased rate of birth defects in children of men who apply the herbicide. 2,4-D is also a suspected endocrine disruptor. For more, see <http://www.beyondpesticides.org/pesticides/factsheets/2,4-D.pdf>. For restrictions on residential use of 2,4-D in various countries, see: <http://en.wikipedia.org/wiki/2,4-D>. Figures cited are the sum of all forms of 2,4-D.

<sup>2</sup> Atrazine, the most heavily used herbicide on corn, has been linked to endocrine disruption, neuropathy and cancer (particularly breast and prostate cancer). Atrazine is regularly detected in drinking water supplies in the Midwest, and has been associated with low sperm counts in men. Exposure to extremely low levels of atrazine can cause sex change and/or deformities in frogs, fish and other organisms. Based on this evidence, and the widespread presence of atrazine in drinking water supplies, the European Union announced a ban on atrazine in 2006. The U.S. EPA re-registered atrazine in 2003 despite objections from scientists and environmental groups. See <http://www.beyondpesticides.org/pesticides/factsheets/Atrazine.pdf> and <http://www.loe.org/shows/segments.htm?programID=06-P13-00016&segmentID=1>.

- When biotechnology companies are forced to admit that GM crops do in fact increase rather than decrease overall pesticide use, they often fall back on a second claim – that increased use of glyphosate is good, because it displaces more toxic herbicides. However, recent trends show that this is decidedly not the case for several widely used and toxic herbicides. Use of both atrazine on corn and 2,4-D on soybeans has increased substantially since 2002.
- Increasing use of 2,4-D on soy (and perhaps atrazine on corn) is largely attributable to the need to control glyphosate-resistant weeds.

## Appendix 3

Intensity of Herbicide Use on Major Field Crops in the U.S.: 1994 - 2007

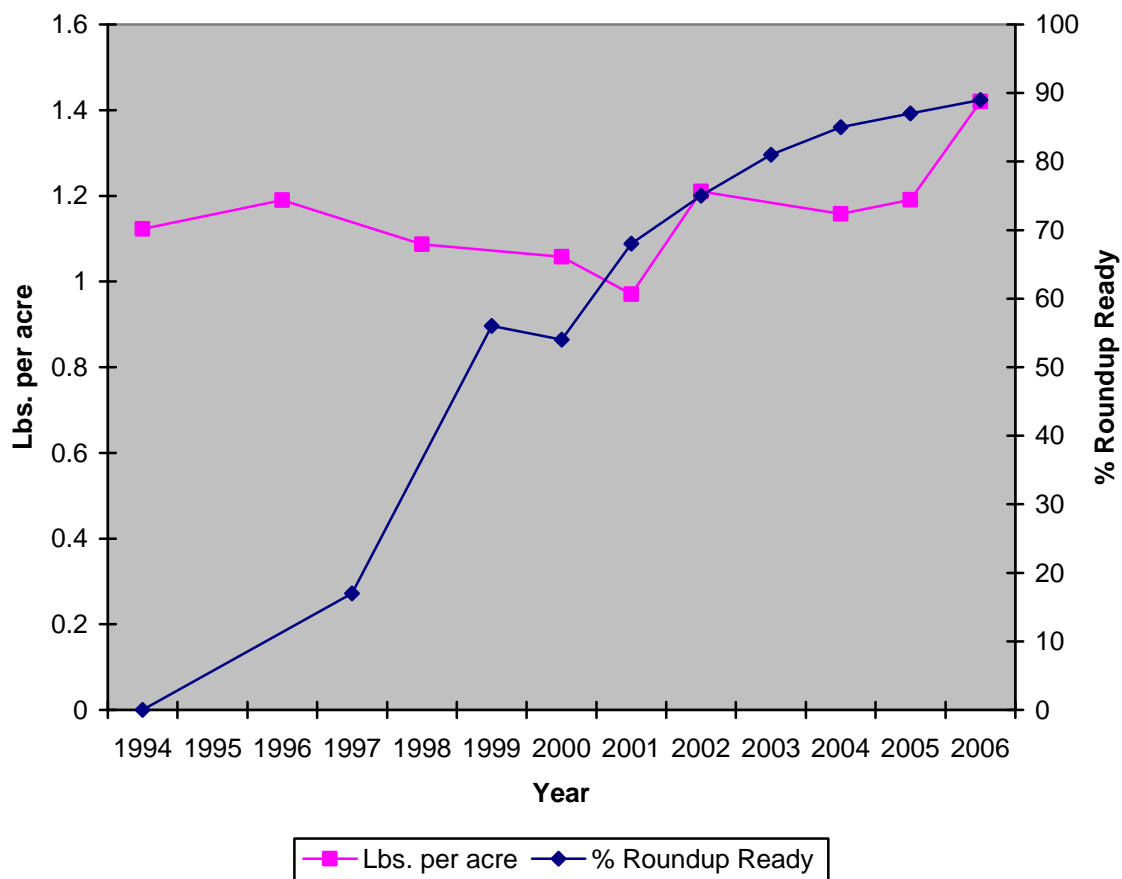


**Notes:** Intensity of herbicide use began rising in 2002 for soybeans and cotton, and in 2003 for corn, as herbicide-tolerant versions of these crops became prevalent.

**Sources:** “Agricultural Chemical Usage: Field Crops Summary,” USDA National Agricultural Statistics Service, for the respective years. Accessible from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560>. The figures represent total herbicide use on the respective crop in the “Program States” included in USDA’s survey, divided by the number of acres planted to that crop in the Program States. The Program States surveyed by USDA represent a high percentage of nationwide acreage planted to the crop (usually more than 80%, often more than 90%). The only assumption made here is that the amount of herbicides applied per acre covered by the survey is equal to that applied on acres not included in the survey. This is accepted practice for calculation of pesticide intensity. For instance, see Table 3.3.3 in Section 3.3: “Biotechnology and Agriculture,” in: “Agricultural Resources and Environmental Indicators, 2006 Edition,” USDA Economic Research Service, Economic Information Bulletin 16, July 2006, accessible from: <http://www.ers.usda.gov/Publications/AREI/EIB16/>. In this 2006 report, USDA for some unexplained reason plotted pesticide intensity on major field crops only up through 2001 or 2002, despite the availability of data for later years.

## Appendix 4

### Soybean Herbicide Intensity vs. Roundup Ready Soybean Adoption

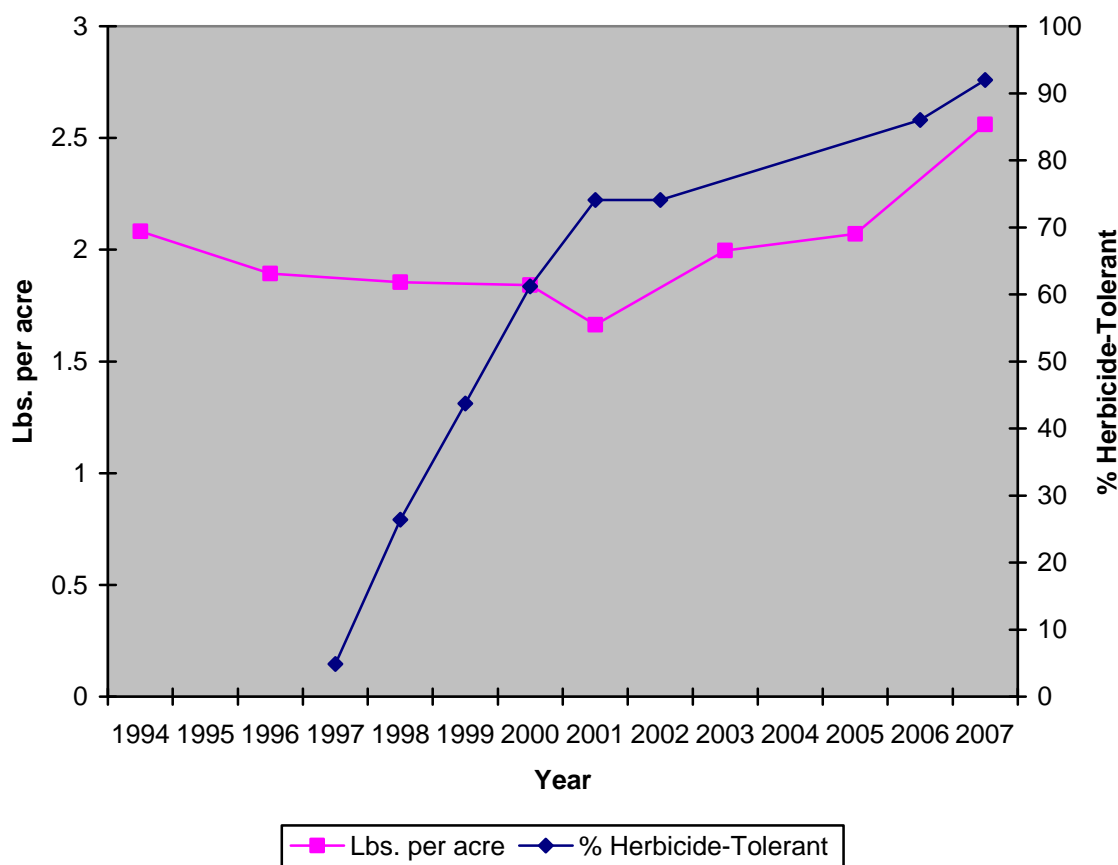


**Notes:** All herbicide-tolerant soybeans are Roundup Ready. RR soy represents by far the most widely planted HT crop. Note the large spike in herbicide intensity beginning in 2002, as Roundup Ready soybean adoption grew to exceed 70% of all soybean acres planted. While correlation is not causation, this large spike in herbicide intensity corroborates the findings of Benbrook (2004) presented on page. 3.

**Sources:** For herbicide use, see: "Agricultural Chemical Usage: Field Crops Summary," USDA National Agricultural Statistics Service, for the respective years. Accessible from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560>. See notes under "Sources" on page 7 for details. For percentage of overall soybean acreage planted to herbicide-tolerant soybeans (all Roundup Ready), see: USDA's Economic Research Service (ERS), see: <http://www.ers.usda.gov/Data/BiotechCrops/alltables.xls>.

## Appendix 5

### Cotton Herbicide Intensity vs. Herbicide-Tolerant Cotton Adoption

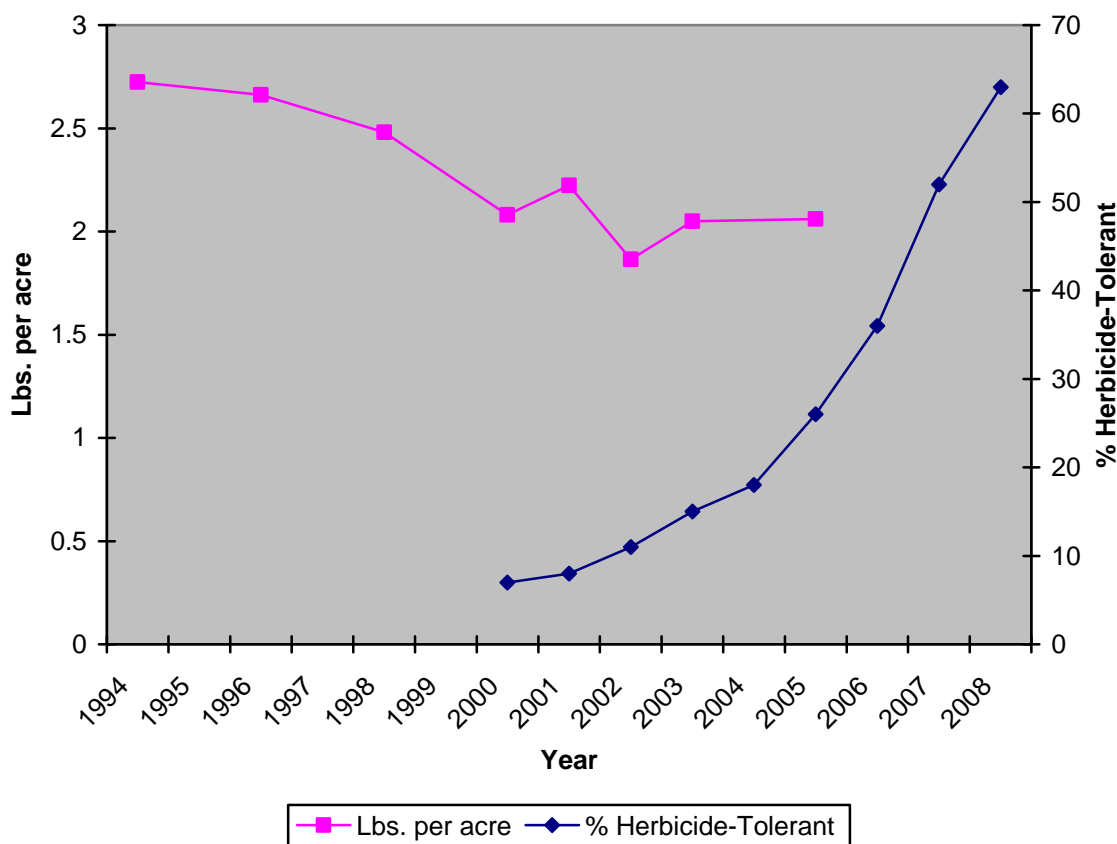


**Notes:** Note the substantial spike in herbicide intensity beginning after 2001, as herbicide-tolerant upland cotton adoption rose to exceed 70% of all upland cotton planted. While correlation is not causation, this substantial spike in herbicide intensity corroborates the findings of Benbrook (2004) presented on page 3. In 2006, 96% of HT cotton was Roundup Ready, 4% was tolerant to glufosinate (LibertyLink).

**Sources:** For herbicide use, see: "Agricultural Chemical Usage: Field Crops Summary," USDA National Agricultural Statistics Service, for the respective years, accessible from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560>. See notes under "Sources" on page 7 for details. Percentage of overall upland cotton acreage planted to herbicide-tolerant cotton from USDA's Agricultural Marketing Service (AMS), which has more reliable statistics on cotton than USDA's ERS. For 1997-2002, see AMS data cited in: May, O.L., F.M. Bourland and R.L. Nichols (2003). "Challenges in Testing Transgenic and Nontransgenic Cotton Cultivars," *Crop Science* 43: 1594-1601. <http://crop.scijournals.org/cgi/reprint/43/5/1594.pdf>. Figures calculated by adding all HT varieties in Table 1. For 2006, see: USDA AMS data in: "Cotton Varieties Planted: 2006 Crop" [http://www.ams.usda.gov/cottonrpts/MNXLS/mp\\_cn833.xls](http://www.ams.usda.gov/cottonrpts/MNXLS/mp_cn833.xls). This figure was calculated by adding percentages of all HT varieties (those with designations R, RR = Roundup Ready or RF = Roundup Ready Flex and LL for LibertyLink). Note that in 2006, 96% of HT cotton was Roundup Ready (Flex); 4% was LibertyLink.

## Appendix 6

### Corn Herbicide Use vs. Herbicide-Tolerant Corn Adoption



**Notes:** Herbicide intensity in corn began to rise modestly in 2003, but is expected to continue increasing as adoption of herbicide-tolerant corn (mainly Roundup Ready corn, though some LibertyLink corn is also grown) continues its dramatic rise. Unfortunately, USDA has not reported pesticide usage on corn since 2005, and its pesticide reporting program was eliminated in 2008, ostensibly due to budget cuts.

**Sources:** For herbicide use, see: “Agricultural Chemical Usage: Field Crops Summary,” USDA National Agricultural Statistics Service, for the respective years. Accessible from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560>. See notes under “Sources” on page 7 for details. For percentage of overall corn acreage planted to herbicide-tolerant corn, see: USDA’s Economic Research Service (ERS), at: <http://www.ers.usda.gov/Data/BiotechCrops/alltables.xls>. Figures are the sum of percentages listed for “herbicide-tolerant only” and “stacked gene varieties.” As defined by ERS, stacked gene varieties always contain an HT trait.