Herbicide-Tolerant Corn in the U.S. is Heavily Treated with Glyphosate Herbicides: Addendum to the Comments Submitted to the USMCA Tribunal by Friends of the Earth U.S.

July 10, 2024

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A tribunal has been established to adjudicate a dispute under the USMCA free trade agreement involving the use of genetically engineered corn and use of glyphosate-based herbicides. Friends of the Earth (FOE) submitted invited comments to the Secretariat managing the dispute resolution process on March 13, 2024. An evidentiary hearing was held before the tribunal on June 26-27, 2024 in Mexico City during which the two parties to the dispute – Mexico and the United States – presented their respective cases.

The purpose of the hearing was to provide the three-member tribunal a chance to ask questions of the parties. The tribunal asked the U.S. delegation what percentage of the GMO corn grown in the U.S. was sprayed with a glyphosate-based herbicide (GBH). The tribunal noted that the frequency of glyphosate use would impact the scope and degree of any public health and environmental impacts associated with the use of this herbicide, and so they wanted to know what percentage of the GMO corn grown in the U.S. was sprayed with a GBH.

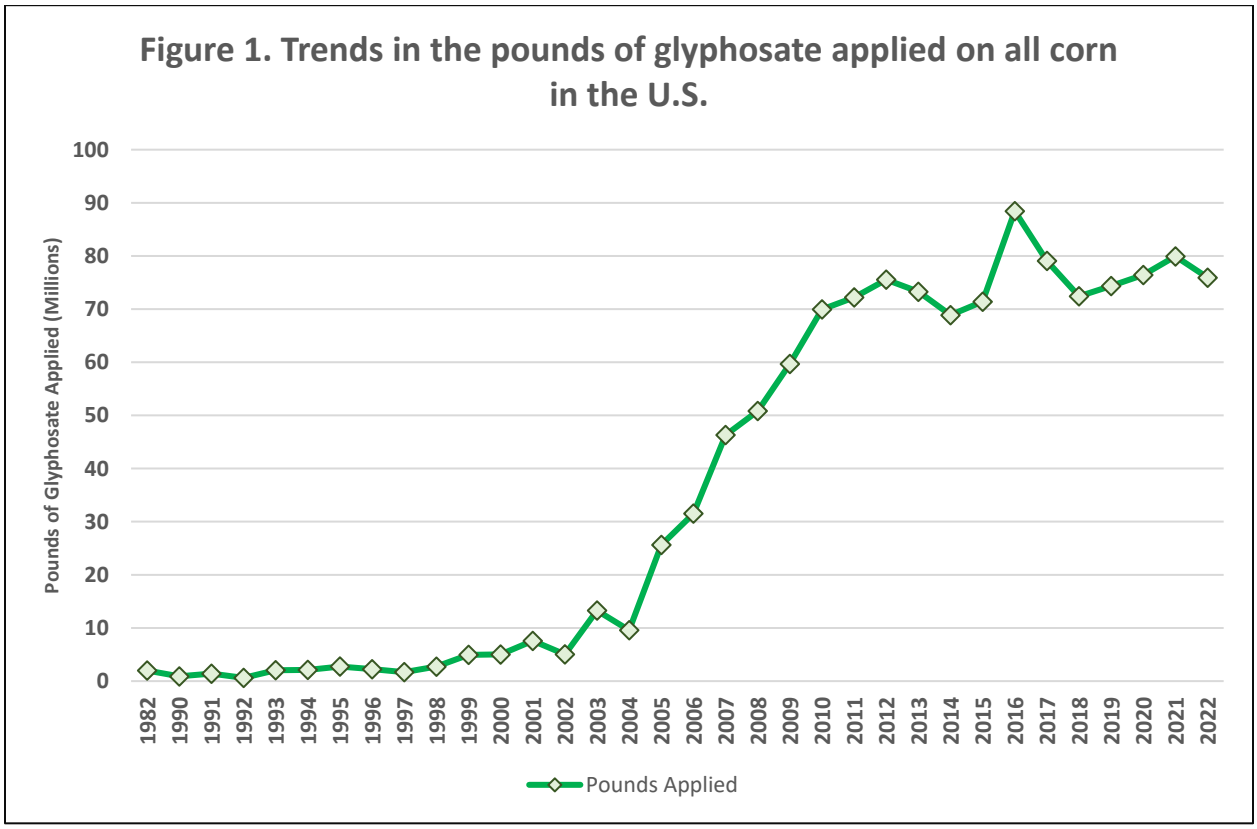
The representatives of the U.S. government provided vague comments about lacking data on the extent of glyphosate use on GMO corn. In this addendum to Friends of the Earth's March 13, 2024 comments, we summarize detailed, readily available U.S. Department of Agriculture (USDA) data on glyphosate use on corn since commercial introduction of glyphosate-tolerant GMO varieties in 2000. It is not known why the U.S. government representatives did not share these data during the tribunal hearing.

Key Finding

The data reviewed herein provides a clear answer to the tribunal's core question – ***almost all corn acres planted to glyphosate-tolerant seeds since 2000 have been sprayed with glyphosate one or more times, and at incrementally higher rates of application***.

As a result, glyphosate use on corn in the U.S. rose from 5 million pounds in 2000 to 88 million pounds at peak glyphosate use on corn in 2016. ***This 17.6-fold increase was essentially all brought about by the planting of glyphosate-tolerant seeds***. In 2022, the most recent year for

which data is available, 75.9 million pounds of glyphosate were used on corn, with 80% of corn acres treated. The upward trajectory in glyphosate use on corn is evident in Figure 1.



The corn acres planted to glyphosate-tolerant varieties increased from 7% of total corn acres in 2000 to 89% in 2016. In 2022, the latest year for which data is available, 90% of acres were planted to glyphosate-tolerant varieties. This increase in corn acres planted to glyphosate-tolerant seed has driven nearly all of the increased use of glyphosate on corn in the U.S.

In recent years, a small percentage of corn acres planted to a glyphosate-tolerant seeds have not been sprayed with glyphosate. Two factors have driven this outcome:

(1) the spread of several glyphosate-resistant weeds has rendered additional GBH applications less effective and uneconomical on some farms, and

(2) by around 2015, the pesticide-seed-biotech industry had moved the glyphosate-tolerant gene into nearly all the foundational corn breeding lines.

As a result, in recent years, the supply of glyphosate-tolerant seed has exceeded demand, so some corn farmers have had to choose among glyphosate-tolerant seed varieties despite not wanting or intending to spray glyphosate on their crop.

Portion of U.S. Corn Crop Planted to Glyphosate-Tolerant Seed

The USDA's Economic Research Service (ERS) compiles detailed data on the traits embedded in the three primary GMO crops grown in the U.S. – corn, soybeans, and cotton. There are two primary GMO traits in corn: herbicide-tolerance (HT), and insect protected, or *Bt*-transgenic varieties.

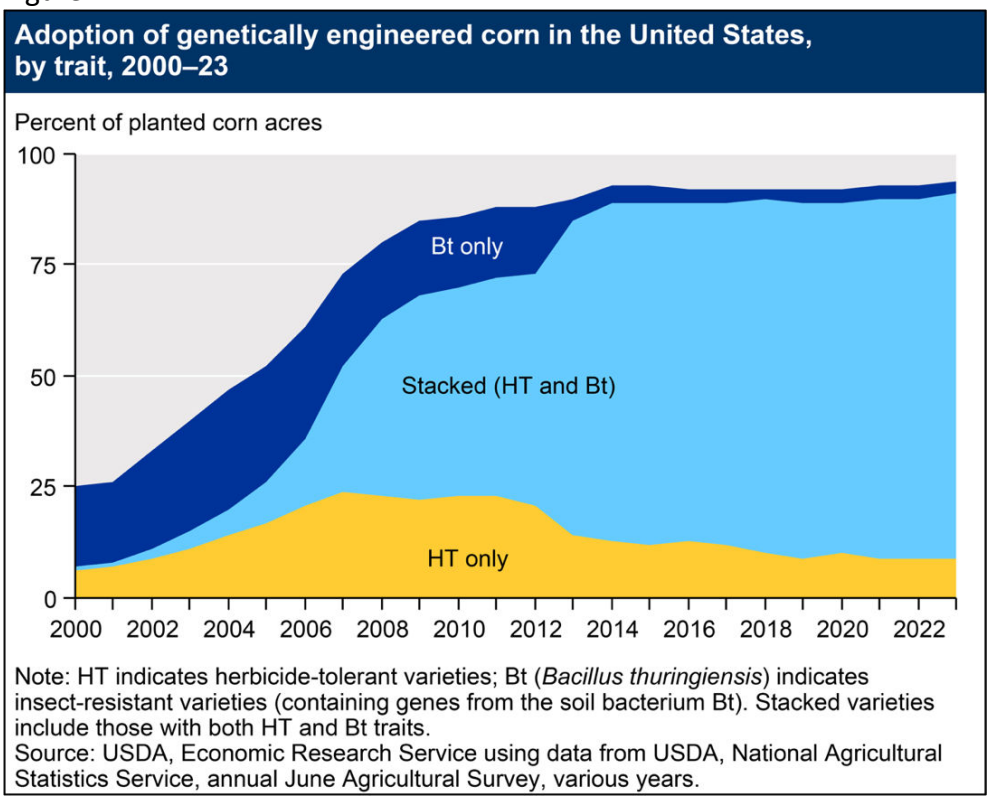
Essentially all GMO corn varieties are engineered to tolerate post-emergent applications of glyphosate. This GMO trait came onto the U.S. market in 2000. Glyphosate-tolerant corn can be sprayed with a GBH through mid-summer. Herbicide-tolerant (HT) corn provides farmers another tool to gain control of weeds that germinate weeks after crop emergence but before the crop-canopy closes (thereby shutting off light reaching the surface of the soil and essentially stopping the emergence of new weeds).

Almost all contemporary GMO corn varieties also express one to five *Bt* and or VIP toxins that can help control insect pests including the European corn borer, corn rootworms, and cutworms (for details, see the March 2024 FOE comments).

Figure 2 is from the ERS website and displays trends in the percent of total corn acres planted to varieties expressing just an HT trait, just a *Bt* trait, and stacked traits (i.e. both HT and *Bt*). Essentially all commercially significant stacked-trait corn varieties are glyphosate tolerant. The total percentage of the U.S. corn crop in any given year planted to a glyphosate-tolerant variety is the sum of the percent of corn acres planted to a variety expressing just an HT trait and the percent expressing stacked traits. The appendix contains a detailed table including this ERS data.

As is clear in the figure below that the percent of corn acres planted with the glyphosate-tolerant trait rose from less than 10% in the early 2000s, to 70% in 2010, and 90% in 2018. It has hovered around 90% since.

Figure 2.



Glyphosate Use on All Corn Acres

Glyphosate-based herbicides came on the market in 1974. About 1.4% of corn acres were sprayed with Roundup/glyphosate in 1982 (the first year USDA data on glyphosate use on corn is available). Between 1992 and 1993, the percent of corn acres treated with Roundup rose from around 1% to 5% as the acreage devoted to no-till planting systems increased.

Commercial corn varieties expressing the glyphosate-tolerant trait become available in 2000, and some 7% of total corn acres were planted to a glyphosate-tolerant variety that year (5.6 million acres). In 2000 about 9% of total corn acres were treated with Roundup/GBHs, or 7.2 million acres, as shown in the appendix table.

Accordingly in 2000, about 78% of all glyphosate-treated corn acres were fields planted to glyphosate-tolerant GMO seeds. It is nearly certain that close to 100% of the corn acres planted to glyphosate-tolerant seed was sprayed with glyphosate that year because of the significant premium charged for the new trait and the then-excellent efficacy of Roundup. Glyphosate-resistant weeds did not become common in corn until the mid-2000s, and initially only then in the southeast. But by 2015, glyphosate-resistant weeds were becoming common wherever GMO corn, soybeans, or cotton were grown.

By 2005, 27 million corn acres were treated with glyphosate and 21.3 million acres were planted to seeds expressing the glyphosate-tolerant trait. Hence in 2005, 79% of the corn acres sprayed with a GBH were planted to a glyphosate-tolerant variety.

The percent of corn acres planted to glyphosate-tolerant corn rose from 26% in 2005 to 63% in 2008, an increase of 37% in just three years. The acres sprayed with a GBH rose sharply too, from 27 million to 50.6 million acres.

In 2010, 61.7 million acres were planted to glyphosate-tolerant varieties. Glyphosate-tolerant acres in 2010 accounted for 92% of all corn acres sprayed with a GBH. Again, nearly 100% of the GMO glyphosate-tolerant acres were sprayed with a GBH. Some 6% of corn acres were not GMO but were sprayed with a GBH, likely in conjunction with no-till.

By 2013, 81 million acres were planted to a glyphosate-tolerant variety but only 73.2 million acres were sprayed with glyphosate. Accordingly, about 7 million acres planted to a glyphosate-tolerant corn variety were not sprayed with a GBH. This inflection point was brought in part by the spread of resistant weeds, but the oversupply of glyphosate-tolerant seed is emerging as the more significant factor.

The supply of glyphosate-tolerant seeds has exceeded farmer demand for several years now. The process of removing the glyphosate-tolerant trait from corn breeding lines takes time and is expensive and the industry has thus far chosen not to do so. As a result, a growing number of corn farmers have to purchase GMO seed with traits they do not want nor need.

In all years since 2013, there were more corn acres planted to herbicide-tolerant varieties than acres sprayed with a GBH. Over this time period, about 4% to 8% of the U.S. corn supply was managed organically or to meet the demand for non-GMO corn. None of these acres were planted to glyphosate-tolerant seed, but many acres planted to non-GMO seed were sprayed with a GBH. The USDA does not collect annual data on the percent of corn acres planted to non-GMO seed nor does it routinely report annual herbicide use on non-GMO corn acres.

The percent of glyphosate-tolerant corn not sprayed with glyphosate likely did not exceed 2% in any given year from 2000 through around 2013, but has incrementally risen in the last decade to perhaps as high as 8% in some recent years.

Changes in the Rate and Number of Applications and Pounds of Glyphosate Applied

Through 1998, the vast majority of corn acres sprayed with Roundup/glyphosate were treated only once per crop year. Such applications were typically made before crop emergence to “burndown” early season weed growth. Prior to the emergence of glyphosate-tolerant crops,

glyphosate could not be sprayed on a growing crop without killing the crop along with any weeds.

Annual details on the average number of glyphosate applications, the average rate of application, the average rate per crop year (number of applications multiplied by the average rate), and pounds of glyphosate applied on all corn acres are in the detailed table in the appendix. The data in the appendix table are from USDA's National Agricultural Statistics Service.

In most years between 1990 and 1998, on average between 0.5 and 1.0 pound of glyphosate was applied per treatment, with most acres sprayed with around two-thirds of a pound of glyphosate. Total pounds applied ranged from a low of 610,000 in 1992 to 2,726,000 in 1998.

Reliance on glyphosate among all corn herbicides was modest through 1998. Glyphosate accounted for less than 1% of total corn herbicide use in most years between 1982 and 1998 and reached just 1.3% in 1998. In the next two years, use about doubled as more corn farmers adopted no-till planting systems and sprayed Roundup before or at planting to kill early-season weeds.

By 2003, just three years after commercial launch of glyphosate-tolerant seeds, glyphosate was applied on 19.7% of all corn acres and 15% of corn acres were planted to glyphosate-tolerant varieties. Because farmers could spray a GBH on their corn crops both before crop emergence, and twice or more during the growing season, the average corn acre was sprayed 1.2 times with a GBH. The rate rose modestly from 1998 to 2003 (0.64 pound to 0.69 pound of glyphosate per acre). Total glyphosate pounds applied increased from 2.7 million to 13.3 million, an almost 5-fold increase. By 2003, glyphosate accounted for just under 8% of total corn herbicide use.

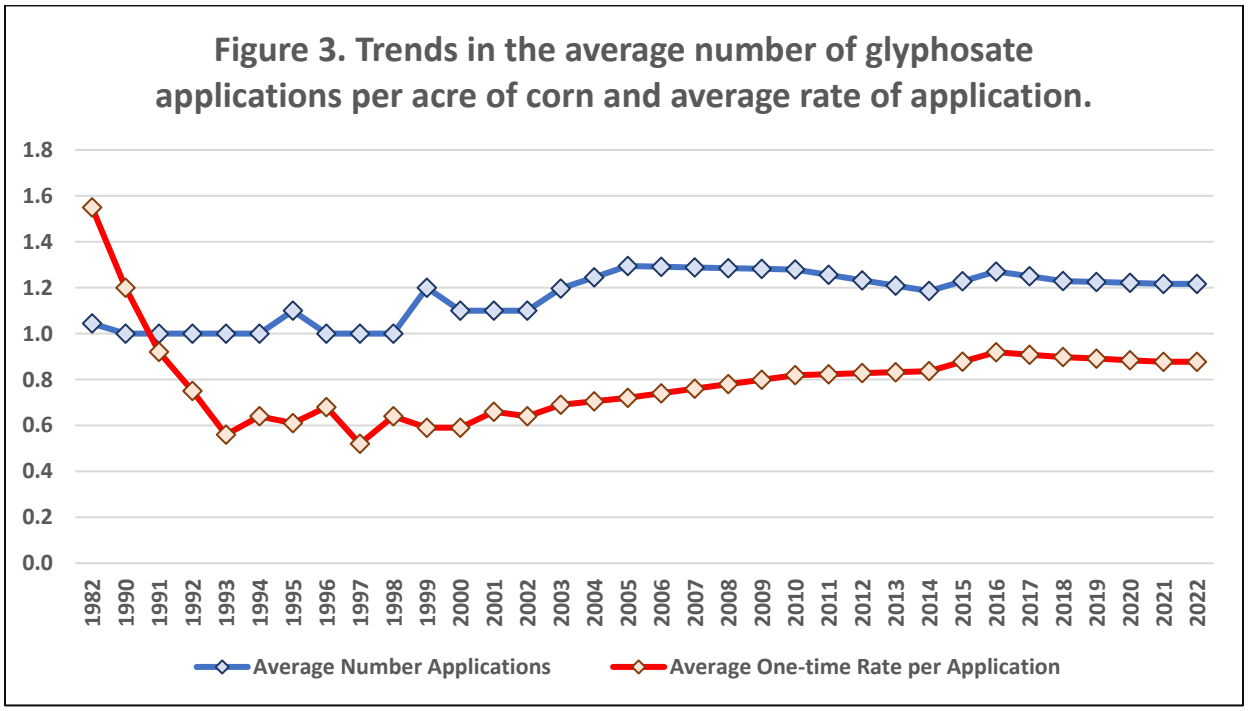
Five years later in 2008, glyphosate use on corn had increased to 50.8 million pounds, almost 4-fold higher than in 2003 and glyphosate accounted for just under 27% of total herbicide pounds applied on corn. Because the efficacy of GBHs was beginning to slip, the average number of applications per acre rose to 1.3 and the average rate of application drifted upward to 0.79 pound.

Glyphosate use on corn rose to a peak level in pounds applied in 2016. A total of 88.4 million pounds of glyphosate was applied that year, nearly 1.0 pound for every acre of corn grown in the U.S. Glyphosate accounted for 35.4% of total corn herbicide use that year.

In terms of peak reliance on glyphosate compared to all other corn herbicides, that occurred the year before in 2015, when 71.4 million pounds of glyphosate applied accounted for 42.9% of total corn herbicide pounds applied.

The average number of glyphosate applications per corn acre has fluctuated between 1.2 and 1.3 since 2002. The average rate of application peaked in 2016 at 0.92 and has fallen modestly since to around 0.9 pound.

Figure 3 displays the trend in the average number of glyphosate applications per acre of corn as well as the average rate of application.



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Appendix: Trends in the Planting of GMO Corn and Glyphosate Use on Corn in the United States: 1971 through 2022 (based on USDA data)

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	1971	1982	1990	1991	1992	1993	1994	1995	1996	1997
Corn Acres Planted	74,179,000	81,857,000	74,166,000	75,957,000	79,311,000	73,239,000	78,921,000	71,479,000	79,229,000	79,537,000
Glyphosate Applications on All Corn										
% Acres Treated	NA	1.5	***1.0***	2.0	1.0	5.0	4.0	6.0	4.0	4.0
Acres Treated	NA	1,235,488	***741,660***	1,519,140	793,110	3,661,950	3,156,840	4,288,740	3,169,160	3,181,480
Glyphosate-Tolerant GMO Corn Percent Acres Planted										
Herbicide-Tolerant Trait Only	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Staked Traits	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Herbicide-Tolerant Trait	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acres Planted	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ratio Glyphosate-Tolerant Acres to Glyphosate Treated Acres	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Glyphosate Number of Applications, Rates, and Pounds Applied on Corn										
Average Number Applications	NA	1.0	***1.0***	1.0	1.0	1.0	1.0	1.1	1.0	1.0
Average One-time Rate per Application	NA	1.55	***1.20***	0.92	0.75	0.56	0.64	0.61	0.68	0.52
Average Rate per Crop Year	NA	1.62	***1.20***	0.93	0.77	0.56	0.67	0.64	0.71	0.53
Pounds Applied	NA	1,998,248	***889,992***	1,412,800	610,695	2,050,692	2,115,083	2,744,794	2,250,104	1,686,184
Corn										
All Herbicdes Pounds Applied	137,402,687	273,544,879	***229,123,249***	233,533,822	241,116,674	233,788,762	230,518,204	202,821,853	226,744,239	225,587,490
Glyphosate as % All	NA	0.73%	***0.39%***	0.60%	0.25%	0.88%	0.92%	1.4%	1.0%	0.7%

Notes:

1. "NA" is "Not Available" because glyphosate-based herbicides were not approved for use until 1974, and the USDA reports data on glyphosate-tolerant corn acres planted from 2000 on.
2. All herbicide use data are from the Pesticide Use Data System (PUDS) developed by Benbrook Consulting Services. Pesticide use data in PUDS are from the USDA's National Agriucltural Statistics Service.
3. Values that are ***bold/italic*** are estimated because of gaps in USDA reporting or the unavailability of data.
4. Corn pesticide use data in years not surveyed by NASS are interprolated based on the assuption that the change in values between two years with reported data occurs in equal increments year to year.
5. All corn herbicide use data in this table are for field corn only, and does not include sweet corn nor food-grade white and other colored corn.
6. Corn acres planted includes a small amount of organically managed acres (likely not in excess of 2% in any one year). The percent of non-GMO corn acres has risen over the past two decades and falls in the 4% to 8% range in recent years.

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	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Corn Acres Planted	80,165,000	77,386,000	79,551,000	75,702,000	78,894,000	78,603,000	80,929,000	81,779,000	78,327,000	93,527,000
Glyphosate Applications on All Corn										
% Acres Treated	5.0	9.0	9.0	13.0	9.0	19.7	13.1	33.0	41.6	50.2
Acres Treated	4,008,250	6,964,740	7,159,590	9,841,260	7,100,460	15,511,645	10,612,220	27,015,081	32,605,180	46,970,195
Glyphosate-Tolerant GMO Corn Percent Acres Planted										
Herbicide-Tolerant Trait Only	NA	NA	6	7	9	11	14	17	21	24
Staked Traits	NA	NA	1	1	2	4	6	9	15	28
Total Herbicide-Tolerant Trait	NA	NA	7	8	11	15	20	26	36	52
Acres Planted	NA	NA	5,568,570	6,056,160	8,678,340	11,790,450	16,185,800	21,262,540	28,197,720	48,634,040
Ratio Glyphosate-Tolerant Acres to Glyphosate Treated Acres	NA	NA	0.78	0.62	1.22	0.76	1.53	0.79	0.86	1.04
Glyphosate Number of Applications, Rates, and Pounds Applied on Corn										
Average Number Applications	1.0	1.2	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.3
Average One-time Rate per Application	0.64	0.59	0.59	0.66	0.64	0.69	0.71	0.72	0.74	0.76
Average Rate per Crop Year	0.68	0.71	0.70	0.77	0.71	0.86	0.90	0.95	0.97	0.99
Pounds Applied	2,725,610	4,944,965	5,011,713	7,577,770	5,041,327	13,288,078	9,582,834	25,620,896	31,529,209	46,312,612
Corn										
All Herbicdes Pounds Applied	213,340,271	186,624,897	177,177,035	175,179,133	149,370,062	169,124,894	174,333,404	173,871,461	168,407,207	203,526,933
Glyphosate as % All	1.3%	2.6%	2.8%	4.3%	3.4%	7.9%	5.5%	14.7%	18.7%	22.8%

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Corn Acres Planted	85,982,000	86,382,000	88,192,000	91,936,000	97,291,000	95,365,000	90,597,000	88,019,000	94,004,000	90,167,000
Glyphosate Applications on All Corn										
% Acres Treated	58.8	67.4	76.0	76.3	76.5	76.8	77.0	78.0	81.0	78.5
Acres Treated	50,569,453	58,227,515	67,025,920	70,101,200	74,427,615	73,192,638	69,759,690	68,654,820	76,143,240	70,781,095
Glyphosate-Tolerant GMO Corn Percent Acres Planted										
Herbicide-Tolerant Trait Only	23	22	23	23	21	14	13	12	13	12
Staked Traits	40	46	47	49	52	71	76	77	76	77
Total Herbicide-Tolerant Trait	63	68	70	72	73	85	89	89	89	89
Acres Planted	54,168,660	58,739,760	61,734,400	66,193,920	71,022,430	81,060,250	80,631,330	78,336,910	83,663,560	80,248,630
Ratio Glyphosate-Tolerant Acres to Glyphosate Treated Acres	1.07	1.01	0.92	0.94	0.95	1.11	1.16	1.14	1.10	1.13
Glyphosate Number of Applications, Rates, and Pounds Applied on Corn										
Average Number Applications	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.3
Average One-time Rate per Application	0.78	0.80	0.82	0.82	0.83	0.83	0.84	0.88	0.92	0.91
Average Rate per Crop Year	1.01	1.03	1.04	1.03	1.02	1.00	0.99	1.07	1.16	1.12
Pounds Applied	50,822,301	59,683,203	69,945,075	72,204,236	75,544,029	73,265,830	68,878,181	71,401,013	88,441,783	79,062,483
Corn										
All Herbicdes Pounds Applied	189,945,812	193,983,069	201,502,419	209,268,373	220,400,341	215,004,879	203,133,493	166,462,299	249,746,915	241,227,488
Glyphosate as % All	26.8%	30.8%	34.7%	34.5%	34.3%	34.1%	33.9%	42.9%	35.4%	32.8%

	2019	2020	2021	2022
Corn Acres Planted	89,745,000	90,652,000	93,252,000	88,579,000
Glyphosate Applications on All Corn				
% Acres Treated	77.0	78.0	79.0	***80.0***
Acres Treated	69,103,650	70,708,560	73,669,080	***70,863,200***
Glyphosate-Tolerant GMO Corn Percent Acres Planted				
Herbicide-Tolerant Trait Only	9	10	9	9
Staked Traits	80	79	81	81
Total Herbicide-Tolerant Trait	89	89	90	90
Acres Planted	79,873,050	80,680,280	83,926,800	79,721,100
Ratio Glyphosate-Tolerant Acres to Glyphosate Treated Acres	1.16	1.14	1.14	1.13
Glyphosate Number of Applications, Rates, and Pounds Applied on Corn				
Average Number Applications	1.2	1.2	1.2	***1.2***
Average One-time Rate per Application	0.89	0.88	0.88	***0.88***
Average Rate per Crop Year	1.08	1.08	1.08	***1.08***
Pounds Applied	74,355,527	76,435,953	79,926,289	***75,921,061***
Corn				
All Herbicdes Pounds Applied	244,803,029	250,116,468	260,357,642	***247,465,718***
Glyphosate as % All	30.4%	30.6%	30.7%	***30.7%***