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*FAQs on "Trends in glyphosate herbicide use in the United States and globally" (*Environmental Sciences Europe *2016 28:3)*

Answers By:
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Background

Why this study?

I am a member of an international team of scientists that published a paper expressing concern over possible health risks from exposures to glyphosate herbicides ("Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement", Myers et al., 2016. *Environmental Health*, 15:19. DOI 10.1186/s12940-016-0117-0).

Rapidly growing dependence on glyphosate by farmers planting genetically engineered (GE) crops is one of the primary reasons concern is rising worldwide over the environmental and public health consequences of glyphosate use. The team asked me to compile data and produce a publishable paper on changes in the volume of glyphosate applied in the U.S. and globally. The goal of my *Environmental Sciences Europe* (ESE) paper is providing biomedical scientists and epidemiologists better understanding of the temporal and regional trajectories of glyphosate use.

What prompted your research into this area?

I got into this area of research because I had tracked annual USDA data releases covering pesticide use since the early 1990s, and I could not understand how replacing herbicides applied at very low (less than 0.01 to pound/acre), to low rates (<0.1 pound/acre) with a moderate dose herbicide like glyphosate (average application rates between 0.66 and 0.75 pound acre) could reduce the overall volume of herbicide use. Turns out I was right to be suspicious, such a switch cannot, and has not reduced per acre herbicide use.

Where and when did the paper come out?

It is published in the peer-reviewed Springer journal, *Environmental Sciences Europe*, and was released online February 2, 2016.

Is the paper available on free of charge?

Yes. One of the reasons that I chose *Environmental Sciences Europe* for this paper is that it offers authors the choice of making their work "open-access." This means anyone can immediately download the full text, free of charge at -- http://dx.doi.org/10.1186/s12302-016-0070-0.

For each paper published via open-access, the author(s) must pay a page charge for processing, to cover the journal's expenses. The page charge for this paper was about $1,100.00, which I paid from a grant from the Ceres Trust.

Major Findings and Implications

Are there any new findings in this paper?

Yes. This is the first peer-reviewed paper ever to report agricultural, non-agricultural, and total glyphosate herbicide use in the U.S. from 1974-2014.

The detailed supplemental tables provide in-depth information on glyphosate use on crops in the U.S. from 1982-2014.

It is the first paper to report global data on glyphosate use in agriculture, non-ag uses, and overall from 1994 through 2015.

This paper is also the first to clearly document the dominant role of GE, herbicide-tolerant (HT) crops in driving glyphosate use higher both in the U.S. and globally.

This is the first paper that reports that glyphosate is the most heavily applied pesticide in history, again both in the U.S. and globally.

Last, it's the first paper showing that ~2/3 of the total volume of glyphosate applied since 1974 has been sprayed in just the last 10 years. This finding has important public health implications, given that glyphosate is a probable human carcinogen linked to cancers of the lymphatic (blood) system. The latency period of non-Hogkins lymphoma in humans, a cancer linked to glyphosate exposures in some studies, is 15-25 years.

The paper says in response to glyphosate-resistant weeds, farmers are using more glyphosate and adding other herbicides to their weed control programs. As a result, average herbicide use per acre on land planted to GE-HT varieties has escalated steadily since the mid-1990s. What is the overall total for herbicide use on GE, herbicide-tolerant crops, and what is glyphosate's share?

In 2014 in the U.S., glyphosate use on the three major GE crops -- corn, soybeans, and cotton -- accounts for just under 90% of the total pounds of glyphosate applied by farmers. The percent is greater than 90% in soybeans, less in corn. Despite a major shift in the last ~5 years to other herbicides to control glyphosate-resistant weeds, the vast majority of these additional herbicides are low-dose active ingredients applied at between 0.01 and 0.1 pound per acre.

So, it takes dozens of acre-treatments to equal one acre-treatment with glyphosate at ~0.8 per acre.

Does the overall increase in use of herbicides on GE-HT crops undermine the pesticide-related argument for GE crops in general, and glyphosate-resistant crops in particular?

Yes, it does.

Pesticide Use per Crop Acre = (herbicide use + insecticide use + fungicide use) per acre. In the mid-1990s when GE-HT crops were introduced, the most widely touted, societal benefit was supposed to be reduction in pesticide use. While *Bt* corn and *Bt* cotton have reduced insecticide use (although to a lesser extent recently, because of the spread of resistant insects), the increase in herbicide use per acre on the three, major GE-HT crops (soybeans, corn, cotton) has been far greater than the reduction in insecticide use per acre on the two *Bt* crops (corn, cotton).

Plus, with each year of widespread use, the gap between total herbicide use on GE-HT acres compared to acres planted to non-GE varieties has widened, as documented in my 2012 *Environmental Sciences Europe* paper entitled *Impacts of genetically engineered crops on pesticide use in the U.S. – the first sixteen years*

Would reduced use of herbicides such as glyphosate force greater use of conventional tillage and less reliance on low- and no-till? What would be the overall effect on the environment?

This is an important and complex question.

In the U.S., farmers still have lots of weed management options, and are moving toward them rapidly now because glyphosate-resistant weeds are so prevalent. But glyphosate will still be widely used for years because the EPSPS gene is built into almost the entire corn, soybean, and cotton seed supply, and glyphosate still controls dozens of weeds.

On farms with two or more glyphosate resistant weeds (probably over 30 million acres now), an increase in tillage is almost certainly going to be one of the tools used, but it need not be a permanent increase. Once the glyphosate-resistant weed seeds are germinated and killed or buried, farmers will have many options other than deep tillage.

In South America though, the linkage between RR soybeans and no-till is rock solid, and the impacts on tillage and erosion as farmers shift away from glyphosate will be much more pronounced and negative.

Implications for Human Health Risks

Isn't glyphosate one of the safest herbicides ever discovered?

In terms of risks posed to organisms other than plants, trees, bacteria, and fungi, yes. Based on mammalian testing done mostly in the 1980s, regulators also have set a very high (low toxicity) chronic Reference Dose for glyphosate. But substantial uncertainty persists over the risks stemming from formulated, glyphosate-based herbicides, for three major reasons.

First, people are not exposed to just glyphosate. This herbicide is always mixed with various "inert ingredients," some of which are much more toxic than glyphosate to certain classes of organisms, and to mammals (and people). Published research has clearly shown the finished product applied by farmers is much more toxic than glyphosate alone, yet essentially all regulations worldwide are based on old and outdated toxicology studies done with glyphosate alone.

Second, the science of toxicology has advanced since the 1980s. Newer tests have shown that glyphosate is genotoxic and an endocrine disruptor. Much more research is needed to more accurately assess the capacity of

glyphosate-based herbicides to trigger birth defects and subtle, epigenetic changes.

Third, the world's leading authority on cancer-causing agents has categorized glyphosate in 2015 as a "probable human carcinogen."

These are three warning signs that should trigger greater discipline in where and how glyphosate-based herbicides are applied, in order to reduce human exposures, while the scientific community sorts out whether the current safety limits embedded in regulations are consistent with the basic standard all pesticides must meet in the U.S. – "a reasonable certainty of no harm."

Are there herbicides available that would pose less risk to humans than glyphosate and if so, what are they?

Yes. The imidazolinone class of herbicides are equally or even even less toxic than glyphosate to mammals. The sulfonylureas are also clearly safer in terms of mammalian risk, in large part because they are applied at very low dose rates (0.01 to 0.1 pound per acre).

But even more important, farmers need to diversify weed management systems and take some pressure of chemical herbicides. The key innovation now recommended by university scientists is for farmers to use "many little hammers."

Glyphosate, as used since year 2000 has been the 20-pound sledgehammer of weed control.

Funding and Outreach

Who funded the study?

The research leading to this paper was done while I was a Research Professor at Washington State University. My "Measure to Manage" program at WSU was supported by the Ceres Trust, UNFI Foundation, and several organic food companies and coops.

How much did the study cost?

The direct staff costs were around $50,000.00.

Why is EWG helping with media outreach?

I have closely followed and occasionally contributed to the work of EWG throughout the organization's history. I am currently working with EWG on projects involving pesticide use and risk, and the impacts of biotechnology. When my three-year appointment at Washington State University ended May 15, 2015, I had an ongoing grant from the Ceres Trust that was moved to EWG, to allow me to continue my work on pesticide use, including the research that led to this new paper on glyphosate use.