History & Future of Glyphosate Herbicide

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Disclaimer

- I've received no funds from Monsanto or any other manufacturer of glyphosate
- I've received no funds from any environmental organization
- I am not a medical doctor or human health scientist
- I am not Anti-Organic (nor Pro-Organic)
- I am not afraid of GMO's

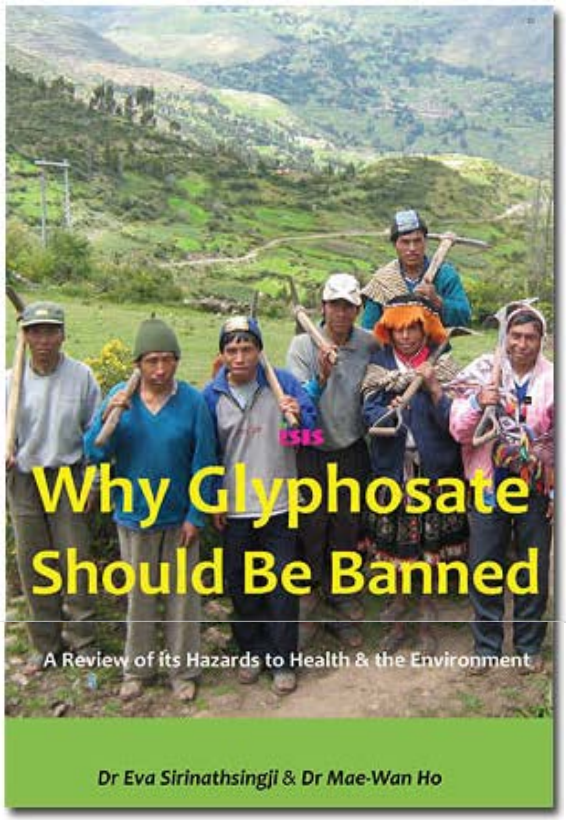
Why Glyphosate Should Be Banned – A Review of its Hazards to Health and the Environment

Posted November 1, 2012 by Dr Mae-Wan Ho & filed under Biodiversity, GMOs, Health & Disease, Soil Erosion & Contamination, Water Contaminaton & Loss.

Glyphosate has contaminated land, water, air, and our food supply; the maximum permitted levels are set to rise by100-150 times in the European Union if Monsanto gets its way as damning evidence of serious harm to health & the environment piles up.

by Dr Eva Sirinathsinghji and Dr Mae-Wan Ho

A fully referenced and illustrated version of this report is posted on ISIS members' website and is otherwise available for download here.



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The Dangers of Glyphosate

It's in our food and water, even personal care products. Glyphosate, the main ingredient in RoundUp, has been shown to cause many serious health concerns, from birth defects to Alzheimer's disease. Banned in many countries, its virtually unregulated in the US...

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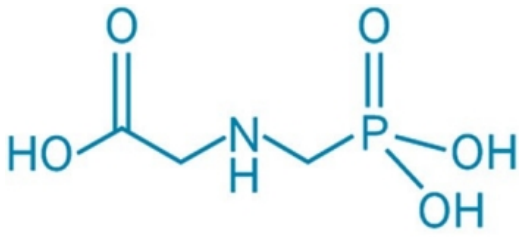
History of glyphosate molecule

- Discovered in 1950 by Swiss chemist Henri Martin, Cilag Corp.
- Early 1970's, John Franz at Monsanto found that derivatives of glyposate had herbicidal activity against perennial weeds.
- First approved in US in 1974 for non-crop use and weed control in stubble. (Pecan orchard use began soon after).
- Patented and sold under tradename Round-Up.
- Patent expired in 2000; now marketed by >40 companies.



Glyphosate

Accolades

- In 1987, John Franz received the US National Medal of Technology and Innovation.
  - Presidential-level honor.
  - Apple computer, super-glue, tandem rotor helicoptor, LED lights, catalytic converters, GPS, etc.
  - "For his discovery of the herbicidal properties of glyphosates which have had significant consequences upon the production of agricultural food and fiber as well as upon agricultural practices throughout the world."

More Accolades—Herbicide and GMO

agricultural technologies have won the nation's technology award. In 1996, Monsanto received the Presidential Award for Sustainable Development. The White House recognized Monsanto for "pioneering sustainable technologies," which included the development of such products as the original Roundup herbicide. Also in 1996, Monsanto received the Presidential Green Chemistry Challenge Award for environmentally responsible systems used in the manufacture of glyphosate herbicides.

- Tillage has been reduced where G-Ready crops have been adopted. Tillage is an environmentally harmful practice that causes significant fossil fuel use, loss of top soil and consequent pollution of surface waters and air.
- Brookes and Barfoot (2006) estimated that G-Ready crop use worldwide in 2005 resulted in a reduction of carbon dioxide emissions and potential additional soil carbon sequestration equivalent to the removal of about 4 million family cars from the road in terms of effects on global carbon balance.

"A once in a century herbicide" (Duke and Bowles, 2008)

- Affordable and long-lasting, systemic control of a broad range of weed plants.
- **Non-volatile, so no atmospheric contamination.**
- As a herbicide, good uptake, excellent translocation to growing sites, nil or limited degradation (in plants) and a slow mode of action are the primary reasons for the excellent efficacy of glyphosate.
- **Tightly bound to soil, no soil activity, defining it clearly as a post-emergent foliar herbicide.**
- Significant tool for directed sprays in row crops and around established trees and vines.

Sod & Strip Weed Control

- Allows equipment travel.
- Good for some irrigation practices.
- Controls soil erosion.
- Limits weed competition for water, nutrients?
- Requires maintenance.

Glyphosate became the backbone of the sod & strip system.

- Longer post-emergence control than contact herbicides like paraquat.
- Low threat of tree/vine injury compared to 2-4D, 2-4-5T, etc.
- Broad spectrum of activity: broadleaf weeds and grasses
- In post-patent era, offered tremendous cost savings over mowing & disking.
- Low level of applicator toxicity

Toxicity

- Glyphosate is less acutely toxic than common chemicals
  - Oral LD 50 (rats)
    - Aspirin 200 mg kg-1
    - Table salt 3000 mg kg-1
    - Acetic Acid 3300 mg kg-1
    - Glyphosate 5100 mg kg–1.
- **Some formulation materials and cationic salt ions used with glyphosate are more toxic than the glyphosate anion itself.**
  - Polyethoxylated Tallow amine (POEA) (Bradberry, et al., 2004)
- **Williams et al. (2000) concluded that, when used according to instructions, there should be no human health safety issues with glyphosate.**

Toxicity-(Borggard & Gimseng, 2008)

The herbicidal function of glyphosate is to prevent the plant from producing essential aromatic amino acids (phenylalanine, tryptophan, tyrosine), but, since animals are unable to produce these amino acids, they are not affected by this function.[8,10] Accordingly, reviews of many investigations of glyphosate toxicity on birds, dogs, fish, mice, rabbits, rats and other animals have shown that glyphosate is largely non-toxic; toxic effects can only be provoked by very high doses.[8,10,12] In addition to very low acute toxicity, these reviews also conclude that glyphosate is non-carcinogenic. Furthermore, glyphosate seems to have no or very limited detrimental effects on microbial populations and processes.[5,25]

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1998 California EPA Study on Environmental Fate of Glyphosate

- Soil adsorption coefficient (Kd=61 g/cm3) and a very low octanol/water coefficient (Kow=0.00033), suggesting that glyphosate has low mobility and only a slight tendency to leach in soil.
- **Linders et al. (1994), classified as very slightly mobile in soil.**
- Glyphosate is inactivated through soil adsorption; it has low leaching potential and very low volatility (Franz et al. 1997).
- **Glyphosate's low Henry's Law Constant indicates that it tends to partition in water versus air and is readily adsorbed onto soil particles.**

http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/glyphos.pdf

In Water

- **Residues undetectable in streams in 3-14 days (Newton et al., 1994).**
- In tests using water from natural sources, the half-life ranged from 35 to 63 days (U.S. EPA, 1986).
- **For all aquatic systems, sediment appears to be the major sink for glyphosate residue.**

In Soil

- Glyphosate is moderately persistent and immobile in soil, as a result of strong adsorption to soil particles.
- **Crops can be planted or seeded directly into treated areas following application because it exhibits essentially no preemergent activity even when applied at high rates (Franz et al. 1997).**
- Soil studies have determined glyphosate half-lives ranging from 3 to 130 days (U.S. EPA, 1990; USDA, 1984).
- **Soil dissipation half-life averaged 44-60 days (Kollman and Segawa, 1995; WSSA, 1989).**

In Soil

- In the soil environment, glyphosate is resistant to chemical degradation, is stable to sunlight, is relatively non-leachable, and has a low tendency to runoff (except as adsorbed to colloidal matter).
- **Less than one percent of the glyphosate in the soil is absorbed via the roots (Ghassemi et al. 1981)**
- Sprankle et al. (1975) found that the prime factor in determining the amount of glyphosate adsorbed to soil particles is the soil phosphate level and that glyphosate is bound to soil through the phosphonic acid moiety. Glyphosate competes with inorganic phosphate for soil binding sites and the degree of binding depends on availability of unoccupied phosphate binding sites.

Is phosphate fertilizer use a factor in glyphosate being root-available in soils?

Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review by Borggard & Gimseng, 2008, Pest Manag Sci 64:441–456 (2008)

- "Clearly"--sorption, degradation and leaching of glyphosate can be very different from soil to soil.
- Degradation of glyphosate in soils is mainly a biological process accomplished by different microorganisms, but bacteria, in particular *Pseudomonas*, seem to be the most important.

On Microbes

- Inactivated and biodegraded by soil microbes at rates of degradation related to microbial activity in the soil and factors that affect this activity (Eriksson, 1975).
  - Degradation by soil microflora occurs under both aerobic and anaerobic conditions.
  - Rates of decomposition depend on soil and microfloral population types.
- Generally had no significant effect on the numbers of bacteria, fungi or actinomycetes in forest soil and overlying forest litter (Stratton G. and Stewart K. 1992).
- Degrades at very low temperatures and does not adversely affect nitrogen fixation, nitrification or denitrification activity (Muller et al, 1981).

In Food Chain

- Low octanol/water coefficient and low fat (lipids) solubility indicate that it has a low tendency to bioaccumulate.
- Little to no potential to bioaccumulate when used in forest systems (Ghassemi et al., 1981).
- Glyphosate residues have minimal tissue retention and are rapidly eliminated from various animal species including mammals birds and fish (Franz et al., 1997).

Is glyphosate carcinogenic?

- Syracuse environmental research associates for US Forest Service, June 1996

The current entry in IRIS, which is U.S. EPA's on-line reference source for risk assessments, for glyphosate indicates that the weight of evidence for the carcinogenicity of the compound is equivocal (U.S. EPA Cancer Assessment Group D: Not classifiable as to human carcinogenicity). This entry was made on October 1, 1993. The classification is also given in U.S. EPA (1992a). The Re-registration Eligibility Decision document on glyphosate (U.S. EPA 1993b, dated September 1993) indicates that the classification has been changed to Group E: Evidence of non-carcinogenicity for humans. This classification is also indicated in U.S. EPA's most recent publication of tolerances for glyphosate (U.S. EPA 1995).

Given the marginal mutagenic activity of glyphosate and the failure of several chronic feeding studies to demonstrate a dose-response relationship for carcinogenicity, the Group E classification is appropriate. There is no indication that glyphosate presents a risk of carcinogenicity to humans.

New Light on Carcinogenicity?

- In 2015, IARC (International agency for research on cancer) **reviewed** five agricultural chemicals in a class known as organophosphates. A summary of the study was published in *The Lancet Oncology*.
- Three agricultural pesticides— malathion, diazinon and glyphosate — were rated as "probably carcinogenic to humans", labeled category 2A.
- IARC review notes that there is limited evidence for a link to cancer in humans. Although several studies have shown that people who work with the herbicide seem to be at increased risk of a cancer type called non-Hodgkin lymphoma,

IARC Ruling: Key Points

- No association with the herbicide and cancer of the brain, esophagus, stomach, prostate, breast, bladder, kidney, colorectal organs, or lung. No association was found with glyphosate and melanoma or soft-tissue sarcoma
- Four case-control studies in USA, Canada and Sweden gave evidence for increased risk of Non-Hodgkin's Lymphoma, particularly for people with high glyphosate exposure.
- "limited evidence for carcinogenicity of glyphosate"
- Acknowledges the Agricultural Healthy Study

The Agricultural Health Study

- (http://aghealth.nih.gov/) an ongoing cohort prospective study of health problems and pesticide exposures in 89,000 American farmers and their spouses.
- Health problems of participants in the AHS have been studied since 1993, with progress reports and results of special investigations emerging with regularity since then.
- De Roos, et al. (2005) concluded from a careful review of the data that there was "no association between glyphosate exposure and all cancer incidence or most of the specific cancer subtypes they evaluated, including Non-Hodgkin's Lymphoma".
- Identified a possible association with multiple myeloma, although the case evidence was small and as such inconclusive.

IARC Ruling Dominoes

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BANS

- Dutch Parliament, November 2015; country-wide ban on non-agricultural use
- Sri Lanka & El Salvador—country-wide bans
- Bermuda—Suspension of product imports.
- France-ban on products that combine glyphosate and tallowamine (POEA)
- Malta—banned glyphosate + POEA products
- California—January 2017 ruling under Proposition 65, requiring labeling on glyphosate products warning of its possible carcinogenicity.
- European Union—extended use through 2017 for further review

Recent Supportive Push-Back

- May, 2016
- U.N.'s Food and Agriculture Organization (FAO) and World Health Organization (WHO) said glyphosate is "unlikely to pose a carcinogenic risk to humans" exposed to it through food.
- From review of the scientific evidence, WHO/FAO also said glyphosate is unlikely to be genotoxic in humans.
  - Not likely to have a destructive effect on cells' genetic material.

The Future?

- Fear and distrust of GMO's (Roundup Ready) has created a global political/cultural agenda against glyphosate herbicide in non- agricultural circles.
- **Lawsuits brought against glyphosate citing IARC may impact manufacturing and availability of the herbicide for on-farm use.**
- Orchard/vineyard industries should diversify herbicide usage and support research into new/alternative chemistries.
- **Growers should make personal decisions about any pesticide use, based on research-based information and safety information contained on EPA labels.**

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Clean cultivation in Georgia. Common up to the late 1960s. Today, clean cultivation is a rarity in Georgia. Photographed 1936, Albany, Georgia by Rulon D. Lewis. From the Jerry A. Payne Collection.

Roundup Ready Crops Influence

Table 1. Transgenic GR crops that have been deregulated in the USA

Crop	Year deregulated
Soybean	1996

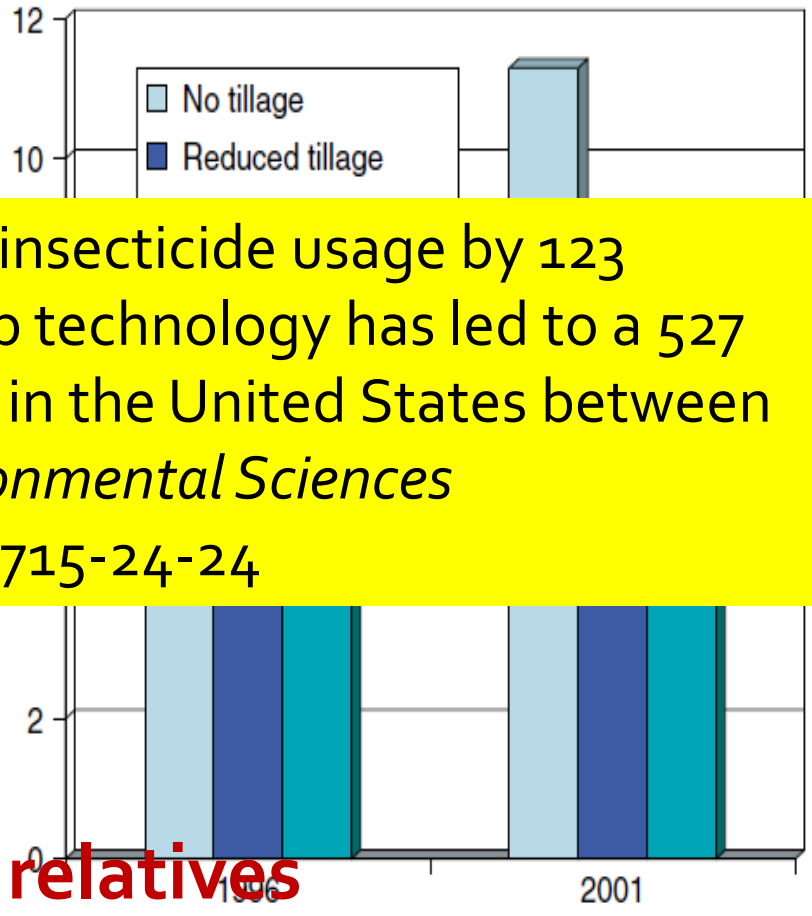

Figure 3. Soybean tillage methods by hectares farmed in the USA in 1996 and 2001. In 1996 and 2001 there were respectively 19.2 and [illegible] million hectares soybeans grown [43]

While Bt-modified crops have reduced insecticide usage by 123 million pounds, herbicide-resistant crop technology has led to a 527 million pound increase in herbicide use in the United States between 1996 and 2011 (Benbrook, 2012). *Environmental Sciences Europe* 2012, **24**:24 doi:10.1186/2190-4715-24-24

Concerns

- **Gene flow into wild plants or relatives**
- **Weed species shift—Super weeds**
- **Overuse of glyphosate herbicides**