Impact of GMOs & Glyphosate on Soil, Plant, Animal and Human Health

Plant & Animal Genome Conference
ONE HEALTH Epigenomics Workshop: From Soil to People
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Don M. Huber, Professor Emeritus, Purdue University

Two Factors to Understand

1. Intended and unintended consequences of the genetic changes
   A. Inserts: traits, promoters, markers
   B. Other (new) products produced

2. Toxicity of Chemicals in the plant
   A. Herbicide containing
   B. Insecticide producing
   Nothing in the GE plant affects glyphosate in plant!

Formaldehyde in Food and Feed

Formaldehyde (ppm)

<table>
<thead>
<tr>
<th>Formaldehyde (ppm)</th>
<th>GMO</th>
<th>Non-GMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glutathione (ppm)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Glyphosate (ppm)</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>EPSPS protein</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Antibiotic markers</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Unknown proteins</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Viral promoters</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

Erosion of Pig Stomachs, Intestines with GMO Soybean/Corn Feed, Iowa

Carman, Vlieger, 2011, 2013

Mice (below) and Squirrels (top) Ignore GMO Corn

Isogenic Triple Stax (GMO) corn ears
Isogenic normal corn ears

Some Activities of Glyphosate

- Persistent
- Organic phosphate
- Growth regulator
- Mineral Chelater
- Pathogen
- Virulence enhancer
- Toxicant
- Antibiotic
- Herbicide

Chelate/immobilizes: Ca, Co, Cu, Fe, Mg, Mn, Ni, Zn, etc.

Photos: Gilbert Hostetler and Howard Vlieger
Nutrients are:
Components of plant and animal tissues and Activators,
Inhibitors, and Regulators of Physiological Processes
Herbicides and many pesticides are chelators

Herbicide action is by soil-borne fungal pathogens

Some Diseases Increased by Glyphosate

Food and Feed Safety Concerns

% Reduced Nutrient Density in RR versus Non-RR*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Alfalfa</th>
<th>Soy Beans**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>13 %</td>
<td>40 %</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>15 %</td>
<td>------</td>
</tr>
<tr>
<td>Potassium</td>
<td>46 %</td>
<td>16 %</td>
</tr>
<tr>
<td>Calcium</td>
<td>17 %</td>
<td>26 %</td>
</tr>
<tr>
<td>Magnesium</td>
<td>26 %</td>
<td>30 %</td>
</tr>
<tr>
<td>Sulfur</td>
<td>52 %</td>
<td>------</td>
</tr>
<tr>
<td>Boron</td>
<td>18 %</td>
<td>------</td>
</tr>
<tr>
<td>Copper</td>
<td>20 %</td>
<td>27 %</td>
</tr>
<tr>
<td>Iron</td>
<td>49 %</td>
<td>18 %</td>
</tr>
<tr>
<td>Manganese</td>
<td>31 %</td>
<td>48 %</td>
</tr>
<tr>
<td>Zinc</td>
<td>18 %</td>
<td>30 %</td>
</tr>
</tbody>
</table>

*Third year, alfalfa, second cutting analysis; glyphosate applied one time in the previous year
**Mature leaf
Toxicity to and Impact of Glyphosate on Poultry Intestinal Microflora  


**Pathogens (Resistant)**  
- *Salmonella enteritidis*  
- *Salmonella gallinarum*  
- *Salmonella typhimurium*  
- *Clostridium perfringens*  
- *Clostridium botulinum*  
- *Clostridium difficile*  
- *Escherichia coli*  
- *Enterobacter cloacae*

**Beneficials (Sensitive)**  
- *Enterococcus faecalis*  
- *Enterococcus faecium*  
- *Bacillus subtilis*  
- *Bifidobacterium adolescentis*  
- *Lactobacillus spp.*  
- *Geotrichum candidum*  
- *Lactococcus lactis subsp. cremoris*  
- *Lactobacillus delbrueckii subsp. bulgaricus*

Environmental Impact of Glyphosate  

Bee Colony Collapse Disorder  

- Lower mineral availability in plant products  
  - Malnutrition  
- Biocidal to *Lactobacillus/Bifidobacterium* in ‘stomach’  
  - Starvation & immunity to mites, viruses, bacteria, stress, etc.  
- Direct toxicity - endocrine disruption, neurotoxicity  
  - Reproduction, disorientation

Effect of Glyphosate on Bee Digestion  

(After Amos, 2011)

- B: Normal honey crop  
- A: C = GMO honeycrops

**Direct Toxicity of Glyphosate**

<table>
<thead>
<tr>
<th>Rate (ppm)</th>
<th>System affected</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>Human cell endocrine disruption</td>
<td>Toxicology 262:184-196, 2009</td>
</tr>
<tr>
<td>0.5</td>
<td>Anti-androgenic</td>
<td>Gasnier et al, 2009</td>
</tr>
<tr>
<td>1.0</td>
<td>Disrupts aromatase enzymes</td>
<td>Gasnier et al, 2009</td>
</tr>
<tr>
<td>1-10</td>
<td>Inhibits LDH, AST, ALF enzymes</td>
<td>Malatesta et al, 2005</td>
</tr>
<tr>
<td>1-10</td>
<td>Damages liver, mitochondria, nuclei</td>
<td>Malatesta et al, 2005</td>
</tr>
<tr>
<td>2.0</td>
<td>Anti-Oestrogenic</td>
<td>Gasnier et al, 2009</td>
</tr>
<tr>
<td>5.0</td>
<td>DNA damage</td>
<td>Toxicology 262:184-196, 2009</td>
</tr>
<tr>
<td>10</td>
<td>Cytotoxic</td>
<td>Toxicology 262:184-196, 2009</td>
</tr>
<tr>
<td>10</td>
<td>Multiple cell damage</td>
<td>Serraloli et al, 2009</td>
</tr>
<tr>
<td>All</td>
<td>Systemic throughout body</td>
<td>Avdon et al, 2009</td>
</tr>
<tr>
<td>1-10</td>
<td>Suppress mitochondrial respiration</td>
<td>Peixoto et al, 2005</td>
</tr>
<tr>
<td>Parkinson’s</td>
<td></td>
<td>El Deversvath et al, 2001</td>
</tr>
<tr>
<td>POEA, AMPA</td>
<td>even more toxic</td>
<td>Seraloli et al, 2009</td>
</tr>
</tbody>
</table>

Effect of Glyphosate on Bee Digestion  

(After Amos, 2011)

- B: Normal honey crop  
- A: C = GMO honeycrops

Children Diagnosed with Celiac Disease at Alberta Children's Hospital

- 266 children  
  - 65% female  
  - Median age of dx 8 yrs  
- GMO Canola
Future historians may well look back and write about our time, not about how many pounds of pesticide we did or did not apply; but about how willing we are to sacrifice our children and jeopardize future generations with this massive experiment we call genetic engineering that is based on false promises and flawed science, just to benefit the “bottom line” of a commercial enterprise.

Dr. Don M. Huber, Professor Emeritus, Purdue University
**Glyphosate in Food**

<table>
<thead>
<tr>
<th>Item</th>
<th>Brand A</th>
<th>Brand B</th>
<th>Brand C</th>
<th>Brand D</th>
<th>Brand E</th>
<th>Brand F</th>
<th>Brand G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread</td>
<td>3</td>
<td>5</td>
<td>17</td>
<td>&lt;.01</td>
<td>127</td>
<td>45</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Sugar</td>
<td>45</td>
<td>3</td>
<td>250</td>
<td>0.5</td>
<td>17</td>
<td>3.9</td>
<td>810</td>
</tr>
</tbody>
</table>

**The 5 R’s of Correction (Problem Solving)**

1. Recognize the problem - LABELING
2. Remove the source
3. Restrict the damage
4. Remediate – Restitution
5. Restoration of the system

**Correction**

<table>
<thead>
<tr>
<th>Prevention</th>
<th>Remove</th>
<th>Remediate</th>
<th>Compensate</th>
<th>Restore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative</td>
<td>Humic acid</td>
<td>Minerals</td>
<td>Microbiome</td>
<td></td>
</tr>
<tr>
<td>Non-GMO</td>
<td>Clinoptilolite</td>
<td>Biologicals</td>
<td>Probiotics</td>
<td></td>
</tr>
<tr>
<td>Bio-coctails</td>
<td></td>
<td>Org. matter</td>
<td>Fecal transplant</td>
<td>Soil health</td>
</tr>
</tbody>
</table>

**Farming is Managing the Ecology**

**Nutrient Availability & Disease Severity**

- **PLANT**
  - Resistance
  - Susceptibility
- **PATHOGEN and PEST**
  - Population
  - Virulence
  - Activity
- **TIME**
- **ABIOTIC ENVIRONMENT**
  - Nutrients
  - Moisture
  - Temperature
  - pH (redox potential)
  - Density, gases
  - Ag Chemicals
- **BIOTIC ENVIRONMENT**
  - Antagonists, Synergists
  - Oxidizers, Reducers
  - Competitors, Mineralizers
  - [Co, Cu, Fe, K, Mn, N, Ni, S, Zn]

**Take-all and Populations of Mn-oxidizing Rhizosphere Bacteria**

- **Mn Availability & Biological Activity**
  - pH: 5.2
  - Mn form: Mn$^{2+}$
  - Available: Yes
  - Biological Activity
  - Mn$^{4+}$
  - Available: No

**Nutrition Changes the Host and Environment for Disease Control**

- Specific nutrients
- Form of nutrient - esp. N
- Time applied
- Rate applied
- Nutrient interactions
- Herbicide interactions
- Disease severity
NUTRIENT BALANCE IS IMPORTANT BECAUSE EACH ELEMENT FUNCTIONS AS PART OF A DELICATELY BALANCED, INTERDEPENDENT SYSTEM WITH THE PLANT'S GENETICS AND THE ENVIRONMENT.

"Hidden Hunger"

Nutrient BALANCE may be a matter of disease or root function! "The roots may be the root of the problem! "The weak link may be underground!"

PLANT Vigor, Growth Stage, Resistance

Environmental Escape Pathogen

AVOIDANCE

DISEASE Saprophytic existence with out the plant

ENVIRONMENT Biological (Vector, Microbial Interaction) Chemical Physical

The interaction of three factors over time determines if a disease will be latent or severe.

The Plant Factory - Storing the Sun's Energy

Photosynthesis and N-fixation

6 CO₂ + 12 H₂O → C₆H₁₂O₆ + 6 O₂

Chloroplast

Mg²⁺

The Harvest is SUGAR and PROTEIN

N₂

Synthesis of Sucrose

Enzyme

Sugar-phosphate synthase

Co-enzyme

Mn²⁺ + Mg²⁺

• If either Mn²⁺ or Mg²⁺ are deficient
  • Glucose and fructose (reducing sugars) accumulate
  • Sucrose synthesis is impaired
  • Juice purity decreases, pests increase

Soil Microorganisms Determine Nutrient Form or Availability

Nitrogen, Iron, Manganese, Sulfur

Factors Affecting N Form, Mn Availability & Some Diseases

Effect of Crop Residues on Nitrification

Metabolism of Different Forms of Nitrogen

Glyphosate

High Soil pH

Lime

Nitrate Fertilizers

Manure

Low Soil Moisture

Loose Seed bed

Potato scab, Rice blast, Take-all, Phymatotrichum root rot, Corn stalk rot
Nutrient Cycles (Biological)

- Carbon
- Nitrogen
  - Urea
  - Nitrate
  - Ammonia
- Proteins
- Phosphorus - ‘phytase’
- Sulfur
- Iron
- Manganese
- Biological ‘sinks’ for all elements

The Nitrogen Cycle

Plant
Protein

Decomposition
(mineralization)

Nitrogen

Atmospheric N

Electrical discharges

Microbial reactions

Nitrification

NH₃ or Ammonium salts

Urea

CO(NH₂)₂

NH₃ or Ammonium salts

Proteins

Phosphorus

Iron

Manganese

Biological sinks for all elements

The Sulfur Cycle

Animals

Protein

In soil

Amino acids

Oxidation

Reduction

H₂S

Some of the organisms involved:

Pseudomonas, Bacillus, Clostridium

Proteus, Serratia, Eschericia

Thiorhodaceae, Chlorobacteriaceae

Beggiatoaceae, Achromatiaceae

Thiobacillus, Rhodopseudomonas

Desulfoibrio, Vibrio, etc.

Effect of Phosphorus Desorption/Remobilization of Glyphosate in Soil on Nutrient Content

Effect of Phosphorus Desorption/Remobilization of Glyphosate in Soil on Nutrient Content

% Mineral Reduction in Roundup Ready® Soybeans Treated with Glyphosate

Young leaves

Mature leaves

Mature grain

Reduced:

Yield 26%

Biomass 24%

After Cakmak et al, 2009

Plant tissue

Ca Mg Fe Mn Zn Cu

Young leaves

40 28 7 29 NS NS

Mature leaves

30 34 18 48 30 27

Mature grain

26 13 49 45

After Bott, 2009

% of UTC

50 60 70 80 90 100

UTC Ca Fe K Mn P Zn

35 d after glyphosate applied

Shikimate (ug/g FW)

0 500 1000 1500 2000 2500 3000 3500 4000

0 5 10 15 20 25 30

UTC Ca Fe K Mn P Zn

40 mg P

30 mg P

20 mg P

10 mg P

0 mg P

35 d after glyphosate applied
### Genetic Engineering’s Impact on the Genetic Code

- The bases in DNA are cytosine, guanine, adenine and thymine so the code of DNA is written in C's, G's, T's and A's (codons). A & T are a “base pair” as are C & G.

- **The Concept of GE** is ‘fossil science’. GE is like a virus infection; not breeding.

- The code used in GM crops is radically changed from that of the recipient and also the named bacterial sources. GE changes the bases, spatial, amino acid, ‘environmental’ & internal relationships.

- There is nothing in the GE plant that does anything to the herbicide applied!

- The genetic material is ‘promiscuous’.

- Always a yield drag.

### Codon Changes for Genetic Engineering Bt in Corn

<table>
<thead>
<tr>
<th>Codon Changes for Genetic Engineering Bt in Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cry1Ab gene in MON810</td>
</tr>
<tr>
<td>Cry1Ab gene in Bt-11</td>
</tr>
</tbody>
</table>

### You can’t see it, taste it, or smell it, but it can slowly kill you!

### Failure to ‘Bulk’ of Russet Potatoes

<table>
<thead>
<tr>
<th>Glyphosate frequency</th>
<th>How applied</th>
<th>No. growers</th>
<th>% Potatoes over 10 oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>None in the previous 2 yrs</td>
<td>None</td>
<td>5</td>
<td>35.3</td>
</tr>
<tr>
<td>1-2 in the previous 2 yrs</td>
<td>Burn down</td>
<td>17</td>
<td>20.2</td>
</tr>
<tr>
<td>Preceding year</td>
<td>RR crop</td>
<td>5</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Total #: 27 Ave: 20.3
Effect of the RR Gene & Herbicide on Root Nodule Mass
After Kremer & Means, 2009

Soybean nodulation at R1, 2010

Effect of the RR Gene & Herbicide on Root Nodule Mass

- The technology inserts alternative EPSPS genes (not blocked by glyphosate in mature tissue)
- More like a virus infection than plant breeding!
- Nothing in the RR plant affects the glyphosate applied to the plant!
  - Reduces nutrient uptake and function
- Causes a “Yield Drag”
- Glyphosate is there for the life of the plant
- Inserted “genes” are promiscuous

GMO for Glyphosate Tolerance
(Roundup Ready® Genes)

Failed Promises of Touted Benefits

- Higher yields
- Fewer pesticides
- Less post-harvest loss
- Improved N-fixation
- Drought and salt tolerance
- Increased photosynthesis
- Greater root growth & function
- Disease resistance
- Lower risks (economic)
- Lower cost
- Greater safety
- Simpler management – resistant weeds & pests

BETRAYAL OF THE PUBLIC TRUST

Some SYMPTOMS of Glyphosate Damage
(Sub-herbicidal depending on rate and exposure time)
- Low vigor, stunting, slow growth
- Leaf chlorosis (yellowing) - complete or between the veins
- Leaf mottling - sometimes with necrotic flecks or spots
- Leaf distortion - small, curling, strap, wrinkling, 'mouse ear'
- Abnormal stem proliferation ('witches broom')
- Bud, fruit abortion
- Retarded regrowth after cutting (alfalfa, perennial plants)
- Lower yields, lower mineral value
- Predisposition to infectious diseases - NUMEROUS!
- Predisposition to insect damage
- Induced abiotic diseases - drought, winter kill, sun scald
- Root stunting, poor growth, inefficient N-fixation and uptake
- Bark cracking

after Univ. of Hawaii; Univ. of Connecticut, Ohio State University

Stomach lining

Non-GM

GM
Are Bees (and Other Invertebrates) the Canaries in Our Coal Mine?

Are Bees (and Other Invertebrates) the Canaries in Our Coal Mine?

Glyphosate

- Indiscriminate use (330 million pounds/yr):
  - Systemic broad-spectrum general use herbicide
  - Herbicide of choice for 85% of GE plants

- Effect on bees
  - Potent endocrine hormone disrupter
  - Potent antibiotic to *Lactobacillus, Bifidobacterium*, etc., - essential microbes for nutrition and pest resistance (immunity)
  - Strong mineral chelater in the bee, plants, & environment

*Glyphosate: Three Rivers, and Anencephaly*, Yakima Herald Republic

THE LETHAL IMPACT OF ROUNDUP ON AQUATIC AND TERRESTRIAL AMPHIBIANS

RICK A. BELLEA
Department of Biological Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania 15260 USA

Abstract. The global decline in amphibian diversity has become an international environmental problem with a multitude of possible causes. There is evidence that pesticides may play a role, yet few pesticides have been tested on amphibians. For example, Roundup is a globally common herbicide that is conventionally thought to be nontoxic to amphibians. However, Roundup has been tested on few amphibian species, with existing tests conducted mostly under laboratory conditions and on larval amphibians. Recent laboratory studies have indicated that Roundup may be highly lethal to North American tadpoles, but we need to determine whether this effect occurs under more natural conditions and in post-metamorphic amphibians. I assembled communities of three species of North American tadpoles in outdoor pond mesocosms that contained different types of soil (which can absorb the pesticide) and applied Roundup as a direct overspray. After three weeks, Roundup killed 0-100% of larval amphibians (regardless of soil present). I then exposed three species of juvenile (post-metamorphic) in anars to a direct overspray of Roundup in laboratory containers. After one day, Roundup killed 68-86% of juvenile amphibians. These results suggest that Roundup, a compound designed to kill plants, can cause extremely high rates of mortality to amphibians that could lead to population declines.

Birth Defects Based on RR Soybean Acreage & Glyphosate drift - Cordoba, Argentina area

- 447% increase in birth defects - (1998-2008)
  - Heart, Anaphlactoid purpura
  - Musculoskeletal, Thyroid

- Increased miscarriages & other reproductive failures
- Cancers in children- and adults, Liver diseases increased
- Neurological disorders increased - esp. in children
- Acute allergies increased

Birth Defects from Endochrine Hormone Disruption in Mammals

"Underbite and cleft palate are epidemic in human newborns. These malformations on human newborns are similar and comparable to underbites and cleft palate on other mammal young and to short upper bill and holes in the upper bills of hatchling birds. These malformations are definitive symptoms of disruption of the thyroid hormones during development in the womb or egg." (Hoy, 2011)
Flawed Safety Evaluations

1983 EPA Scientist: “Our viewpoint is one of protecting the public health when we see suspicious data.” Unfortunately, EPA has not taken that conservative viewpoint in its assessment of glyphosate’s cancer causing potential.

“There are no studies available to NCAP evaluating the carcinogenicity of Roundup or other glyphosate-containing products. Without such tests, the carcinogenicity of glyphosate-containing products is unknown.”

“Tests done on glyphosate to meet registration requirements have been associated with fraudulent practices.”

“Countless deaths of rats & mice are not reported.”

“Data tables have been fabricated”

“There is a routine falsification of data”

“It is also somewhat difficult not to doubt the scientific integrity of a study when the IBT stated it took specimens from the uteri of male rabbits for examination.”

Wikipedia, 2012

Bt Egg Plant Toxicology Evaluation

Gallagher, 2011

Summary:

* The study failed to meet international standards for evaluation (OECD 1998; Codex Alimentarius, 2003 c-c)

* There were serious departures from normal scientific standards

* Studies submitted are ‘woefully inadequate to determine safety’

* Consists of substandard and extremely misleading interpretation of the results presented

* Independent study can not uphold the government report of approval