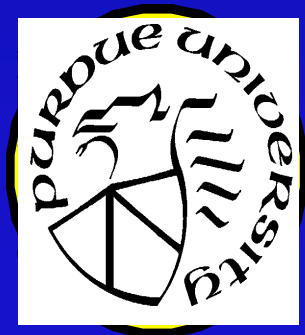
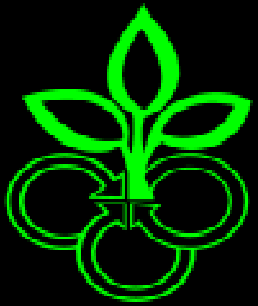


# **Glyphosate Effects on Crops, Soils, Animals, and Consumers**

**Europe - UK  
October 31, 2011**

**Don M. Huber**

**Emeritus Professor of Plant Pathology  
Purdue University, West Lafayette, IN**



# The Importance of Reducing Stresses

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**Potential**

-

**Stresses**

=

**Yield**

There is no free lunch!

# Nutrients are:

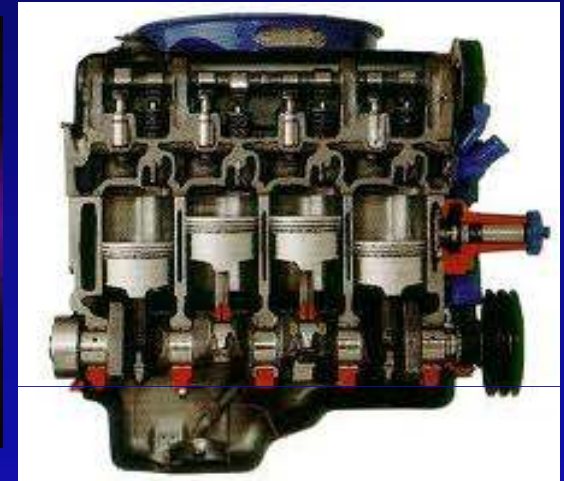
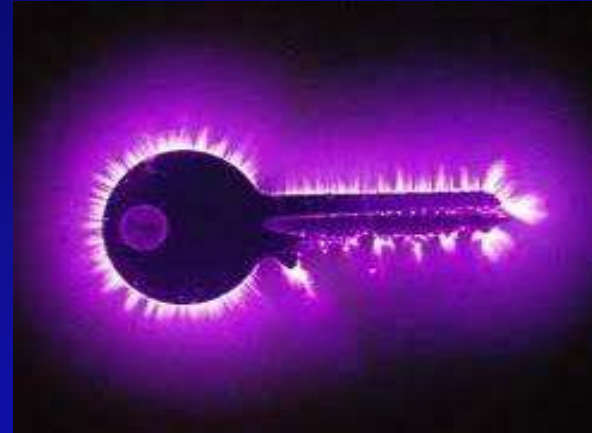
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Components of plant parts as well as

Activators,

Inhibitors,

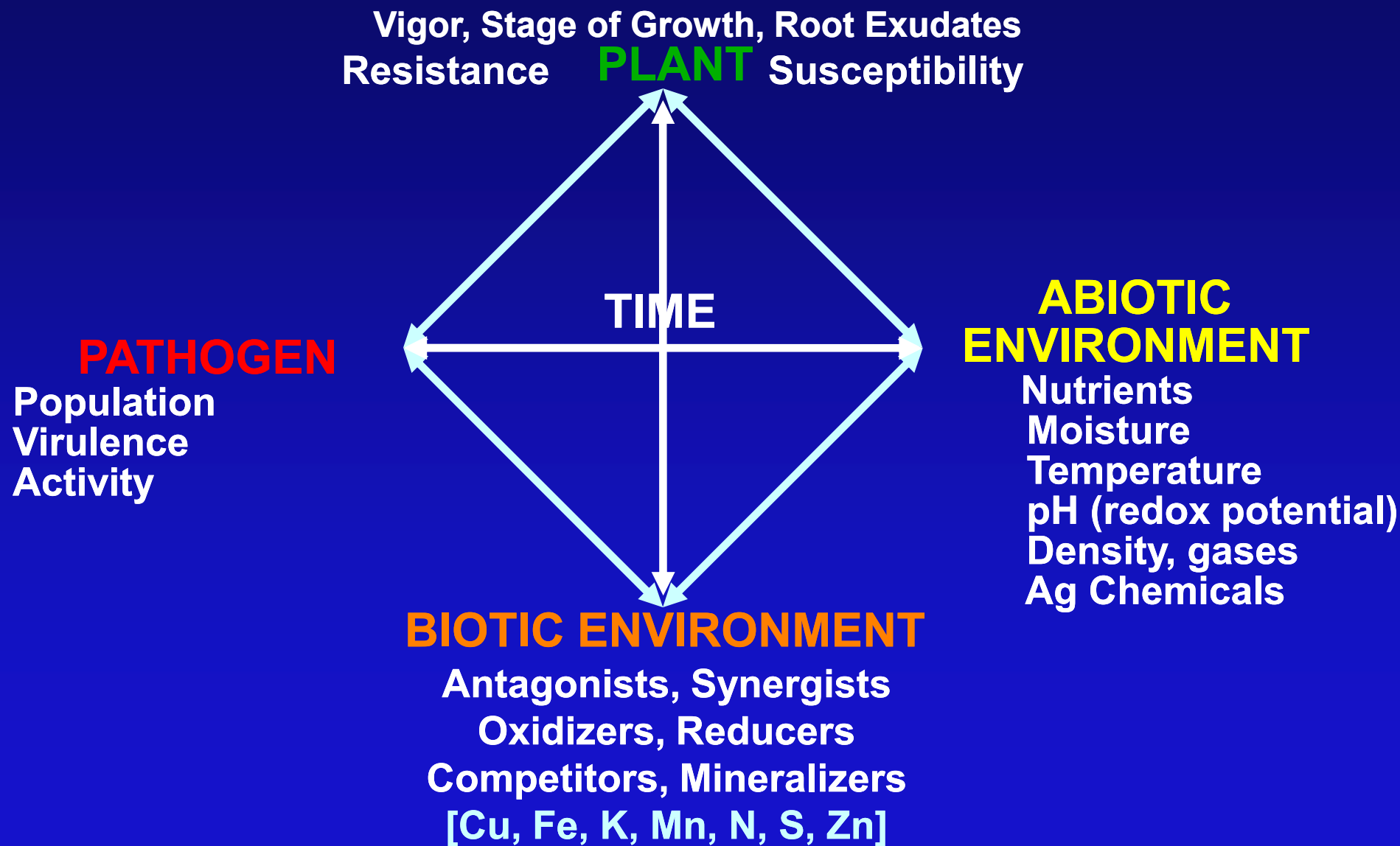
and Regulators



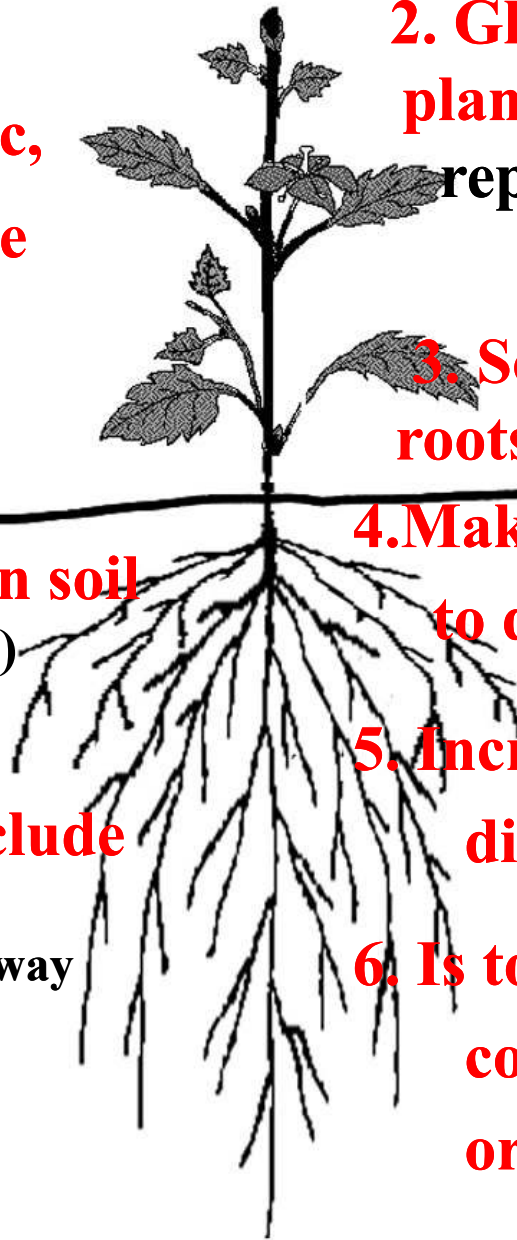
of Physiological Processes

Many herbicides and pesticides are chelators

# Interacting Factors Determining Nutrient Availability and Disease Severity



**1. Glyphosate is a systemic, broad-spectrum herbicide that intensifies stress**



**2. Glyphosate accumulates in plant tissues (shoot and root tips, reproductive structures, and legume nodules)**

**3. Some glyphosate moves into roots and is released into soil**

**4. Makes the plant susceptible to diseases**

**5. Increases virulence of soil-borne disease organisms**

**6. Is toxic to normal biological control and other beneficial organisms**

**7. Glyphosate accumulates in soil (fast sorption; slow degradation)**

Desorbed by phosphorus

**Beneficial soil organisms include**

N-fixing microbes

Any with bacterial shikimate pathway

N-fixing organisms

Mycorrhizae

Biological control organisms

Earthworms

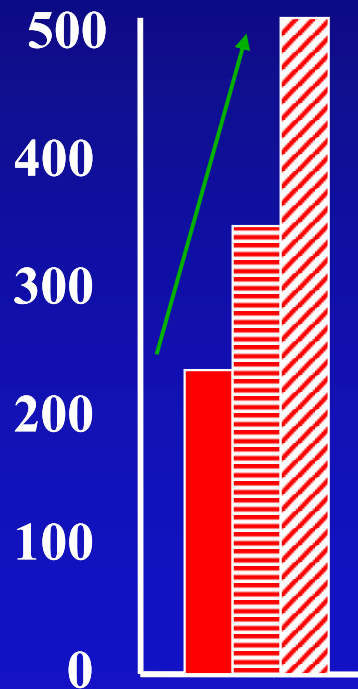
Plant Growth Promoting organisms

**Schematic of glyphosate interactions**

# Microbiocidal Activity of Glyphosate

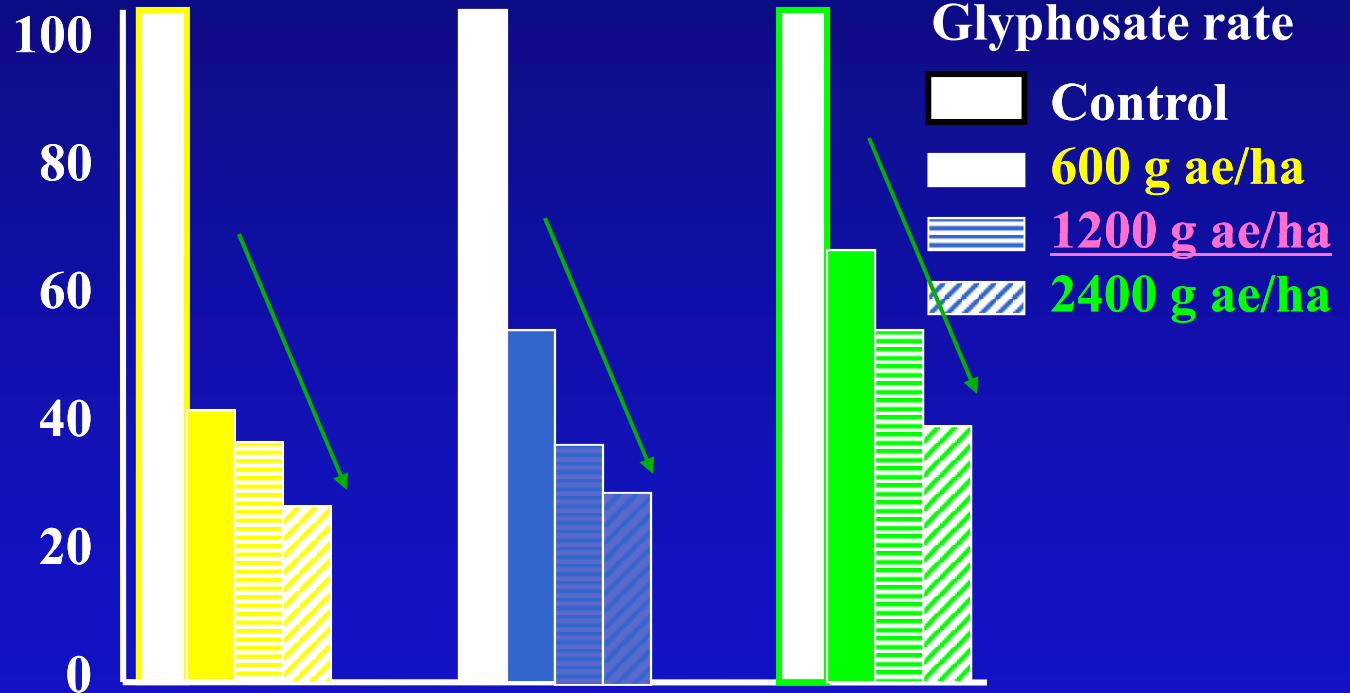


Fusarium % change



Fusarium root colonization

% of control

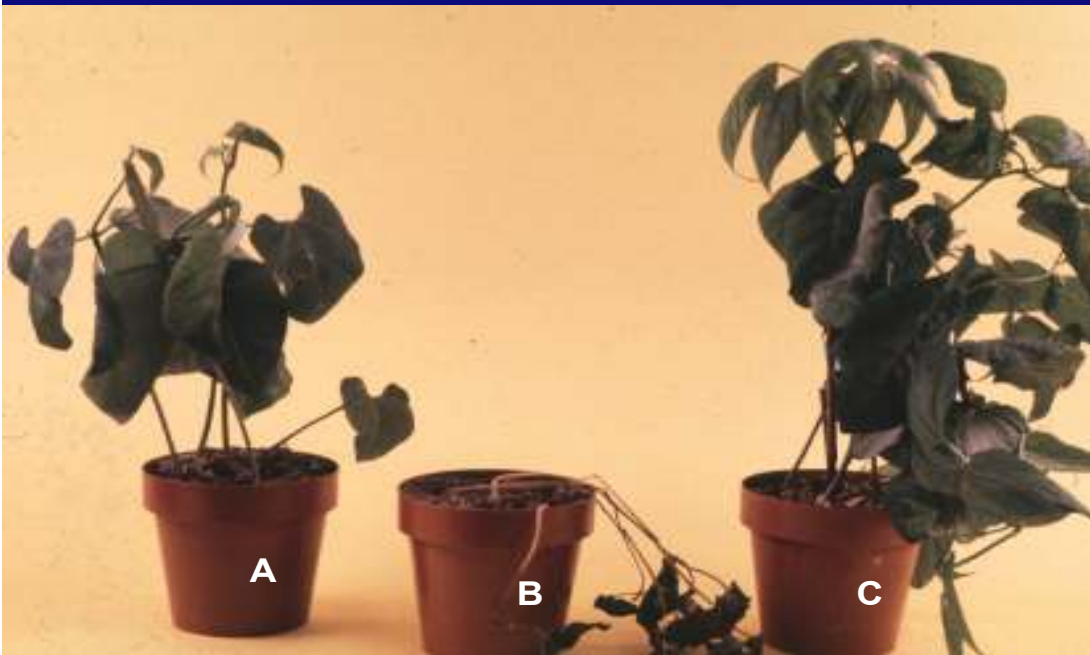


Pseudomonads Mn reducers IAA producers

After Zobiolo et al., 2010  
 Kremer, 2010

# Herbicide action is by soil-borne fungal pathogens

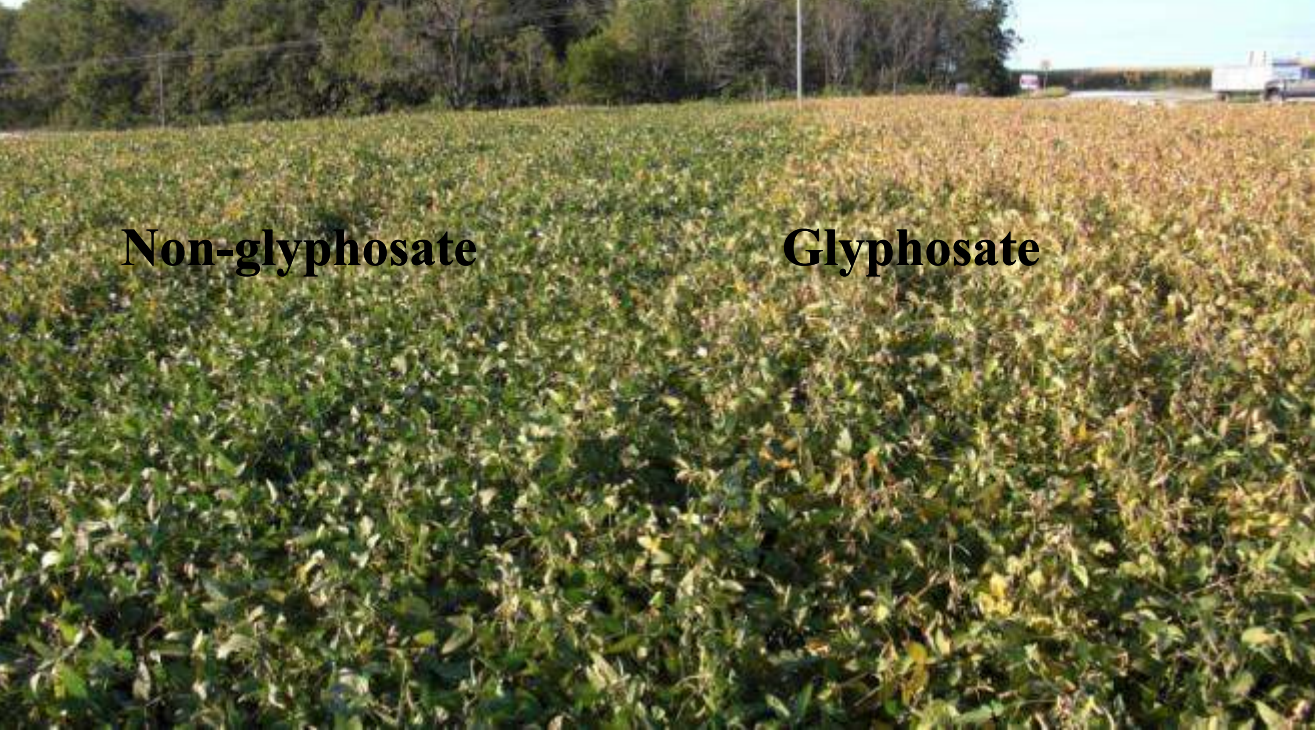
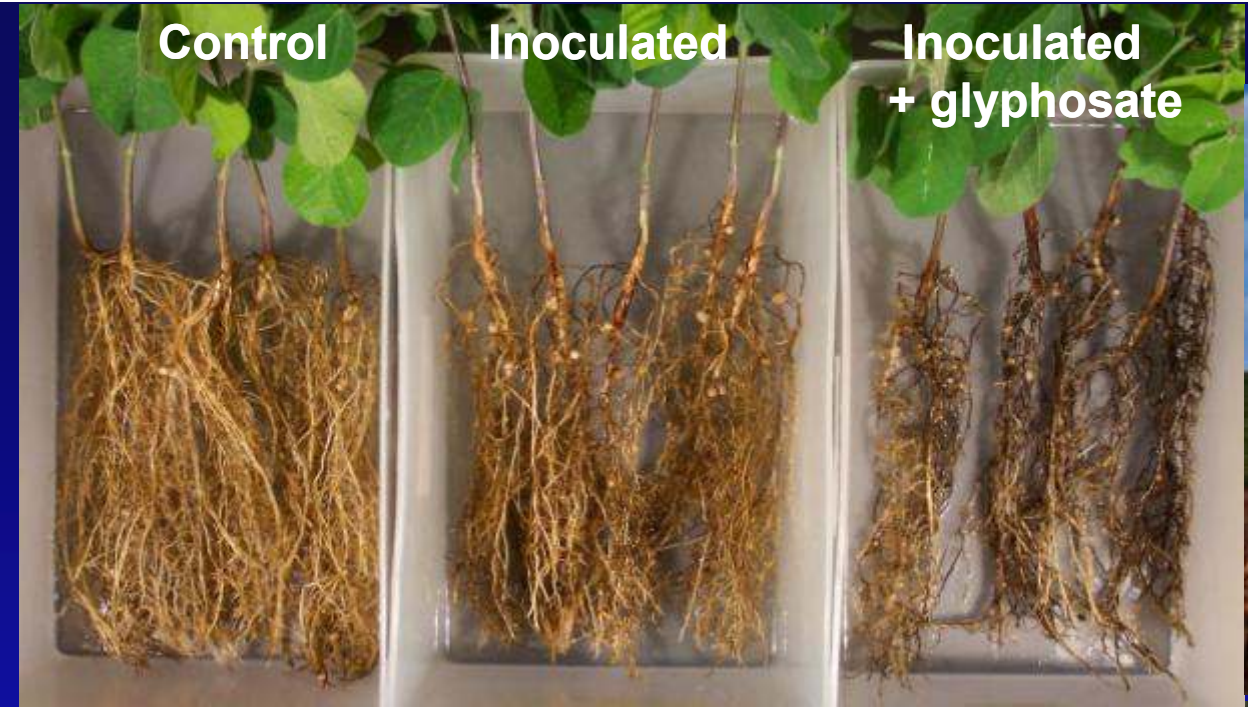
## Glyphosate Increases Disease Susceptibility



Glyphosate Sterile soil    Glyphosate Field soil    No glyphosate Control

Effect of glyphosate on susceptibility to anthracnose. A) hypersensitive response; B) non-limited response after glyphosate is applied.

After Rahe and Johal, 1988; 1990; See also Johal and Huber, 1999; Schafer et al, 2009.



# What's Special About Genetic Engineering for Glyphosate Tolerance? (Roundup Ready® Genes)

[Greatly expanded usage of glyphosate]



- The technology inserts an alternative EPSPS enzyme that is not blocked by glyphosate in *mature* tissue

- **There is nothing in the RR plant that operates on the glyphosate applied to the plant!**

Glyphosate chelation is not selective it immobilizes nutrients

Ca, Co, Cu, Fe, K, Mg, Mn, Ni, Zn

**Reduces nutrient uptake**

- **Can cause a “Yield Drag”**
- **It is there for the life of the plant**

# Reduced Nutrient Efficiency of Isogenic RR Soybeans (After Zobiolo et al, 2008, 2009)

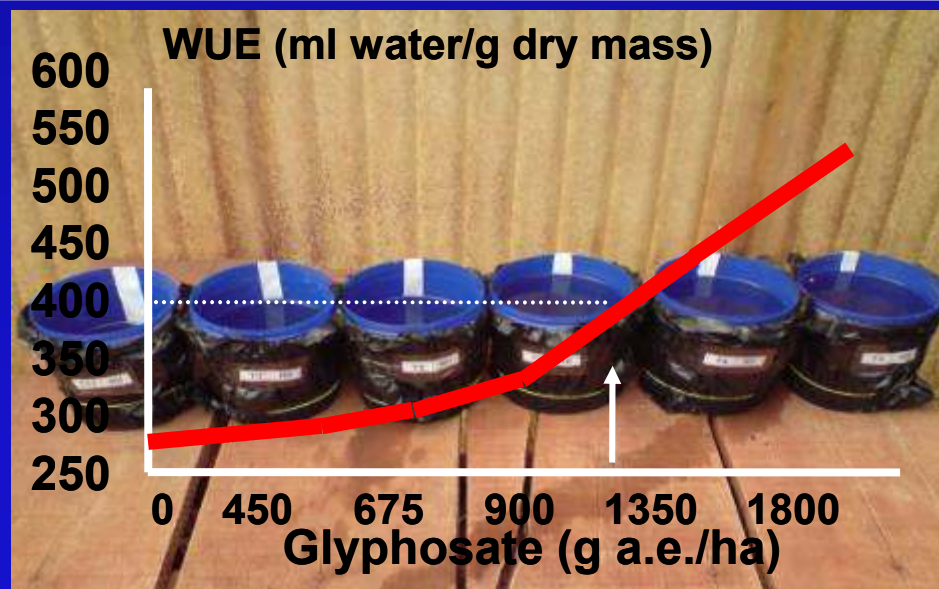
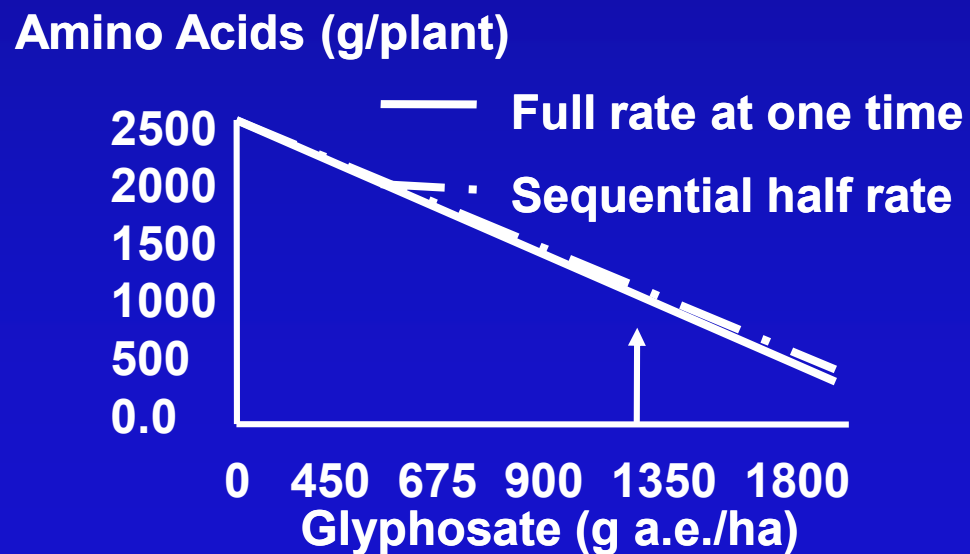
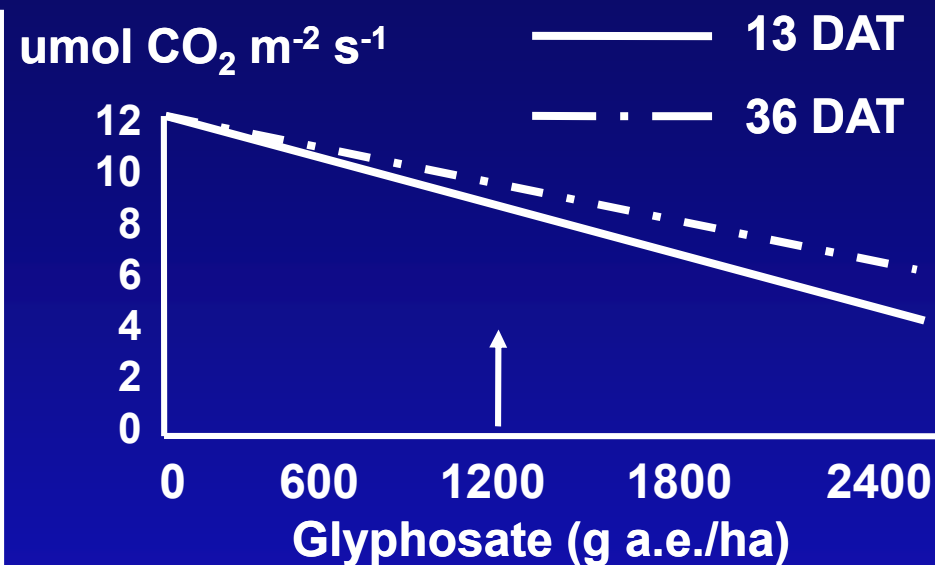
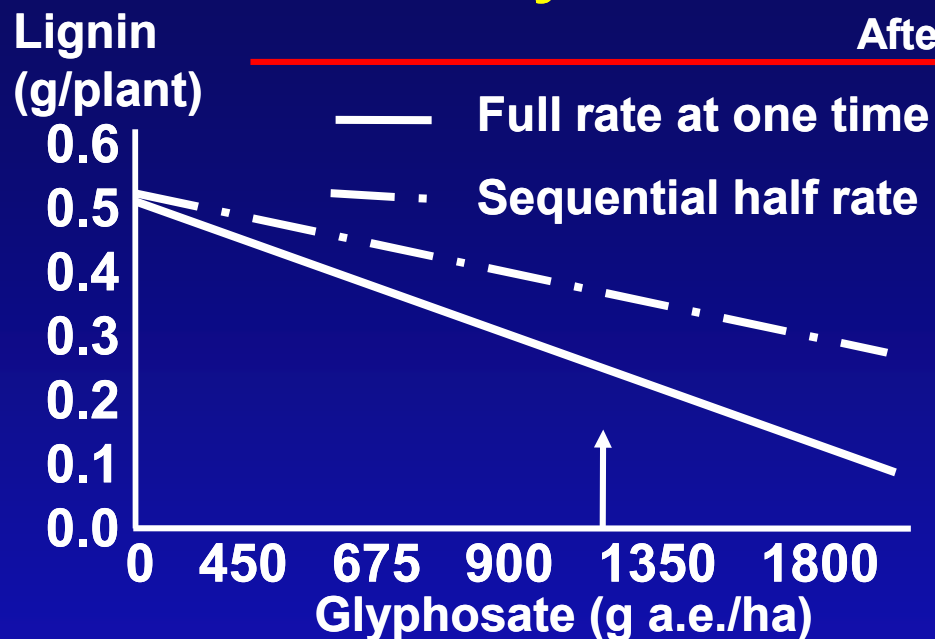
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Tissue:	Mn	Zn
Isoline	%	%
Normal	100	100
Roundup Ready©	83	53
RR + glyphosate	76	45

Copper, iron, and other essential nutrients  
Were also lower in the RR isoline and reduced  
further by glyphosate!

# Effect of Glyphosate on Lignin, AA, Water Use Efficiency, and Photosynthesis of 'Glyphosate-Resistant' Soybeans

After Zobiolo, 2009



# % Mineral Reduction in Roundup Ready® Soybeans Treated with Glyphosate

Plant tissue	Ca	Mg	Fe	Mn	Zn	Cu
Young leaves	<u>40</u>	<u>28</u>	7	<u>29</u>	NS	NS
Mature leaves	<u>30</u>	<u>34</u>	<u>18</u>	<u>48</u>	30	<u>27</u>
Mature grain	<u>26</u>	<u>13</u>	<u>49</u>	<u>45</u>		

## Reduced:

Yield 26%

Biomass 24%

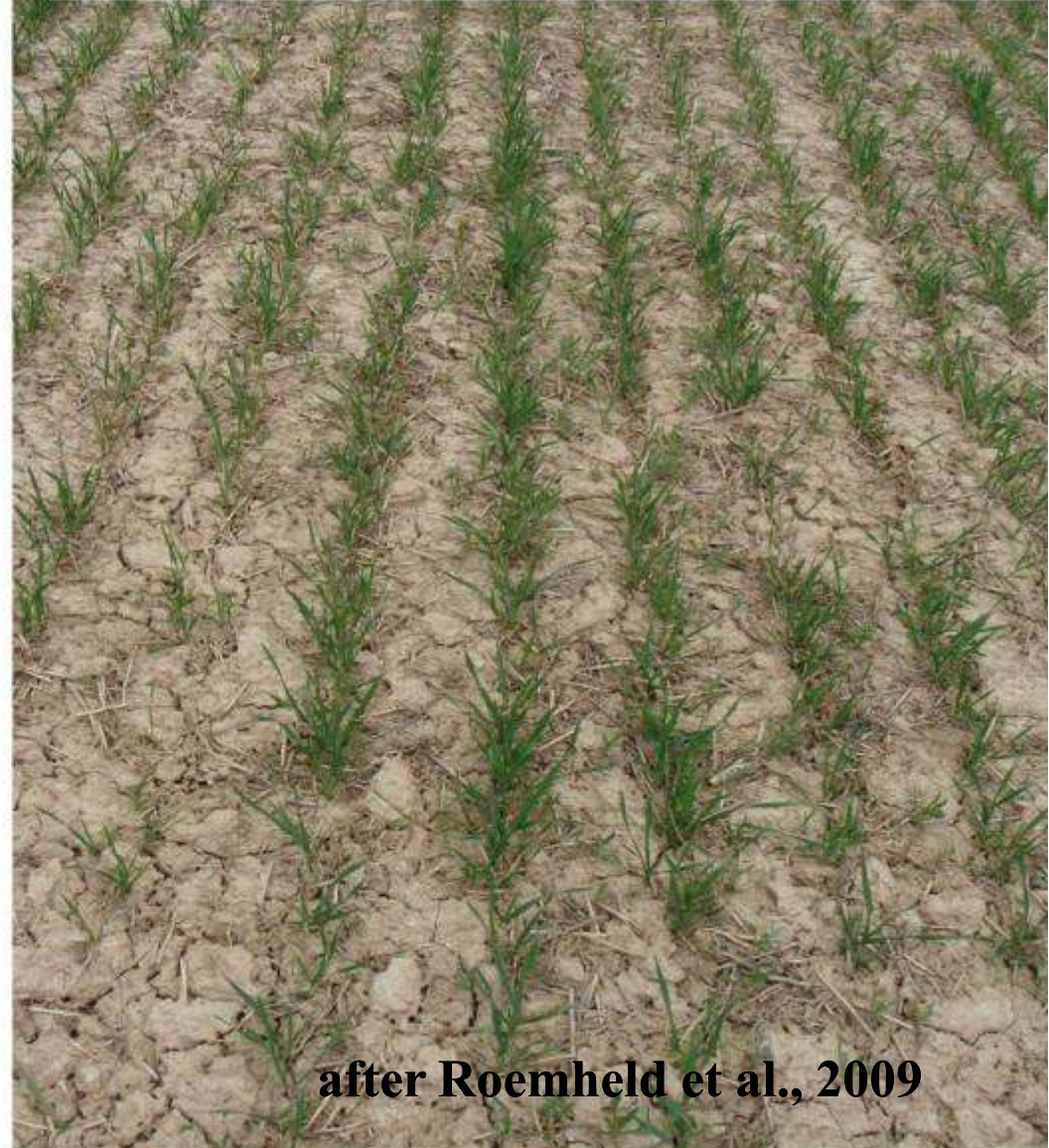
After Cakmak et al, 2009

# Long-term Effect of Glyphosate

**Short-term glyphosate use (1year)**



**Long-term glyphosate use (10 years)**



after Roemheld et al., 2009

# Food and Feed Safety Concerns

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## ➤ Increased levels of mycotoxins

- Fusarium toxins (DON, NIV, ZEA)
- Aflatoxins

## ➤ Gene flow

- Weeds
- Soil microbes
- Intestinal microbes

## ➤ Nutrient deficiency

- Cu, Fe, Mg, Mn, Zn

## ➤ Direct toxicity of residual glyphosate

- Infertility - endocrine system
- Birth defects, teratogenicity
- Cell death - Disease resistance

## ➤ Allergenic reactions to foreign proteins

Aris & Leblanc, 2011  
Benachour et al, 2007  
Carmen, et al., 2011  
Fernandez, et al., 2009  
Gasnier, et al., 2009  
Heiman, 2010  
Matzk et al, 1996  
Seralini et al., 2010, 2011  
Smith, 2010  
Walsh, et al., 2000  
Watts, 2009

# **% Reduction in Alfalfa Nutrients by Glyphosate\***

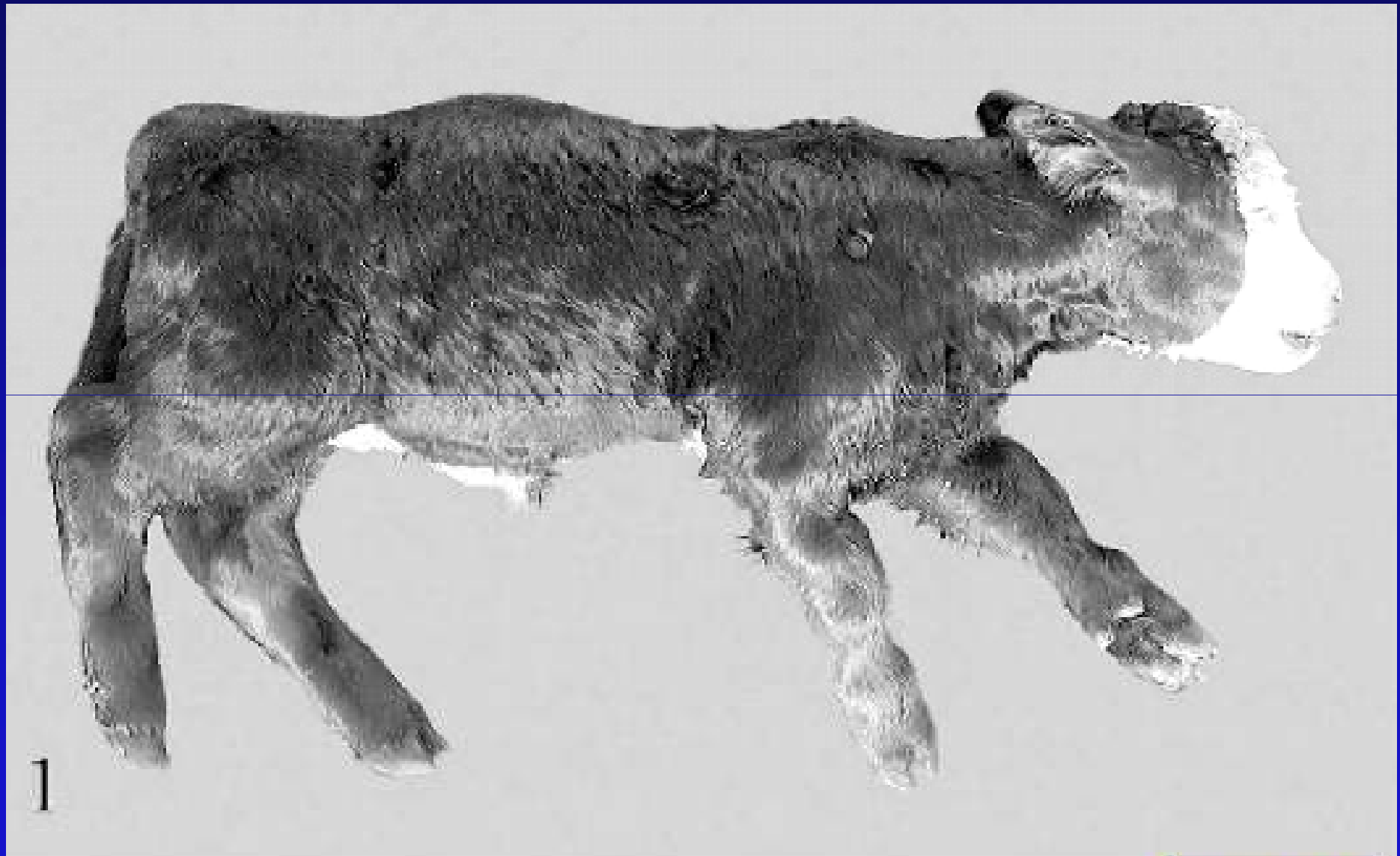
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<b>Nutrient</b>	<b>% reduction compared with Non-RR</b>
<b>Nitrogen</b>	<b>13 %</b>
<b>Phosphorus</b>	<b>15 %</b>
<b>Potassium</b>	<b>46 %</b>
<b>Calcium</b>	<b>17 %</b>
<b>Magnesium</b>	<b>26 %</b>
<b>Sulfur</b>	<b>52 %</b>
<b>Boron</b>	<b>18 %</b>
<b>Copper</b>	<b>20 %</b>
<b>Iron</b>	<b>49 %</b>
<b>Manganese</b>	<b>31 %</b>
<b>Zinc</b>	<b>18 %</b>

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\*Third year, second cutting analysis; Glyphosate applied one time in the previous year

# Stillborne Calf from Manganese Deficiency



McLaren P-J et al. Vet Pathol 2007;44:342-354

Veterinary Pathology

# U.S. Cattlemen's Association Statement to Congress

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“Cattle ranchers are facing some puzzling - and, at times, economically devastating problems with pregnant cows and calves. At some facilities, **high numbers of fetuses are aborting for no apparent reason**. Other farmers successfully raise what look to be normal young cattle, only to learn when the animals are butchered that their carcasses appear old and, therefore, less valuable.”

“The sporadic problem is so bad both in the United States and abroad that in some herds around 40-50 percent of pregnancies are being lost.”

“Many pesticides and industrial pollutants also possess a hormonal alter ego.”

**“The viability of this important industry is threatened.”**

Source: Testimony of the Ranchers-Cattlemen Action Legal Fund, United Stockgrowers of America, to the Senate Agriculture Committee July 24, 2002.

# Feed Source Effect on Stomach Liner Color, 2010

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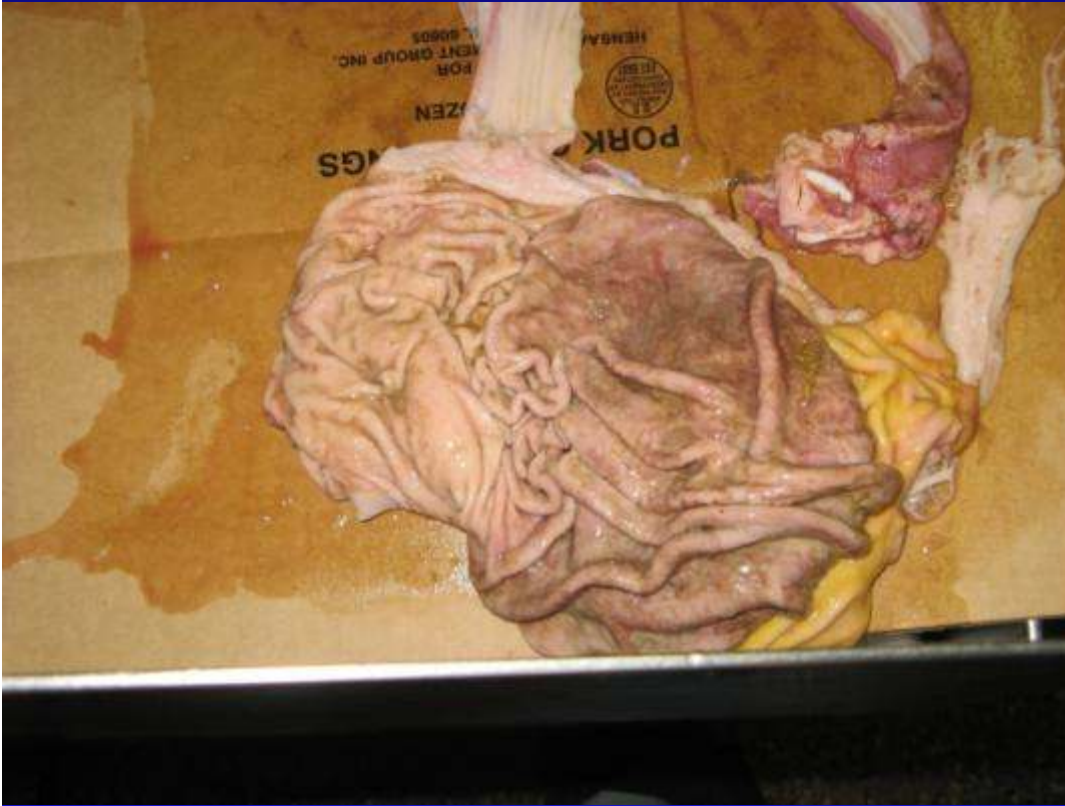


# Effect of the GM “Gene” Proteins in Corn/Soybeans on Pig Stomachs

2011

**Non-GMO Feed**

**GMO Feed**



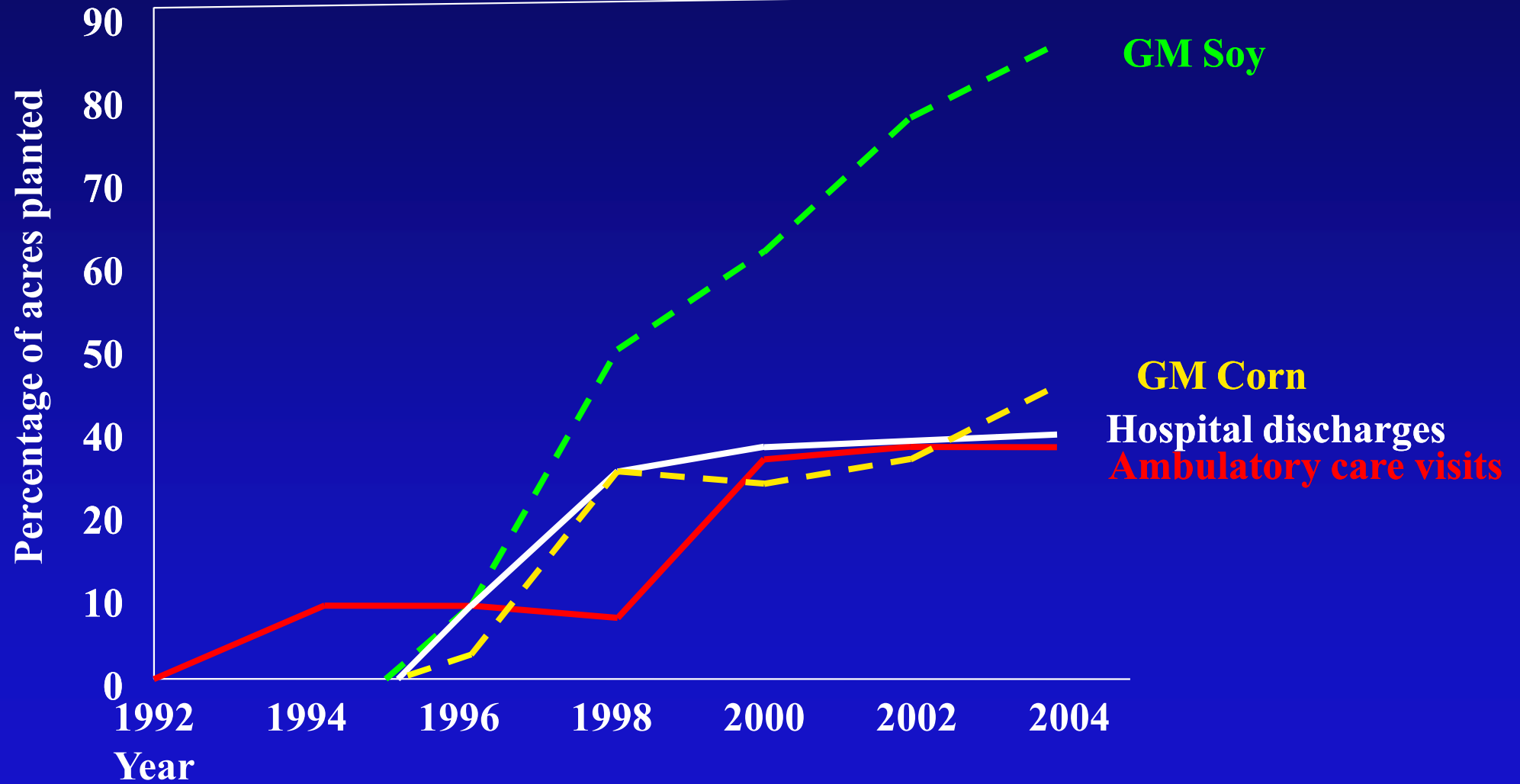
**Normal color**



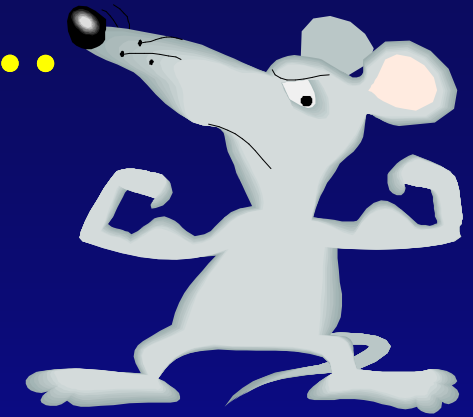
**Inflamed, irritated**

# Inflammatory Bowel Disease, USA

Cases/100,000 population



# And the Mice Prefer.....



**GMO  
Corn**



**Non-GMO  
Corn**



**Photos: Gilbert Hostetler**

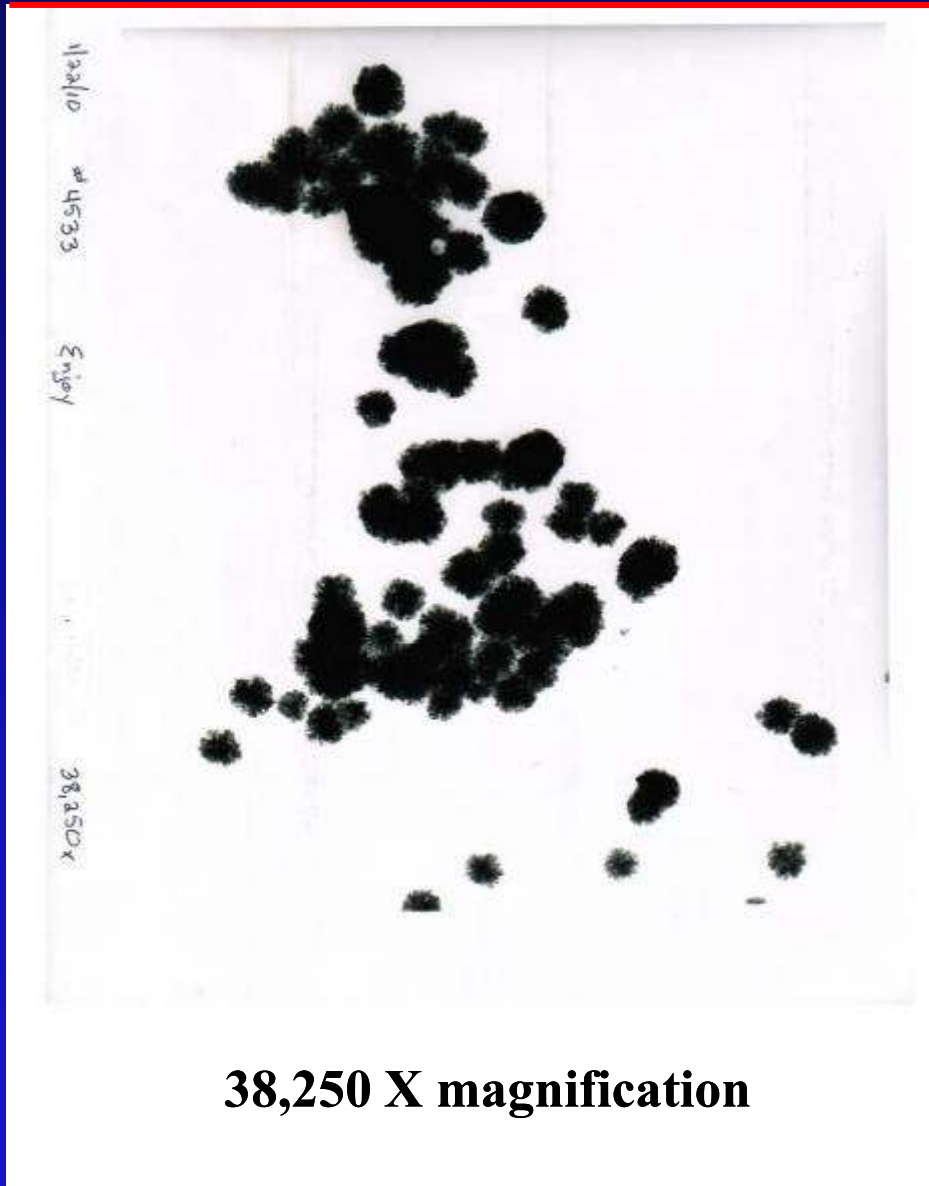
# Direct Toxicity of Glyphosate

Rate (ppm)	System affected	Reference
0.5	Human cell endocrine disruption	Toxicology 262:184-196, 2009
0.5	Anti-androgenic	Gasner et al, 2009
1.0	Disrupts aromatase enzymes	Gasnier et al, 2009
1-10	Inhibits LDH, AST, ALF enzymes	Malatesta et al, 2005
1-10	Damages liver, mitochondria, nuclei	Malatesta et al, 2005
2.0	Anti-Oestrogenic	Gasnier et al, 2009
5.0	DNA damage	Toxicology 262:184-196, 2009
5.0	Human placental, umbilical, embryo	Chem.Res.Toxicol. J. 22:2009
10	Cytotoxic	Toxicology 262:184-196, 2009
10	Multiple cell damage	Seralini et al, 2009
10	Total cell death	Chem.Res.Toxicol. J. 22:2009
All	Systemic throughout body	Andon et al, 2009
1-10	Suppress mitochondrial respiration	Peixoto et al, 2005
Parkinson's		El Demerdash et al, 2001
POEA, AMPA even more toxic		Seralini et al, 2009

**Late term  
'Spontaneous  
Abortion'  
(Miscarriage)**

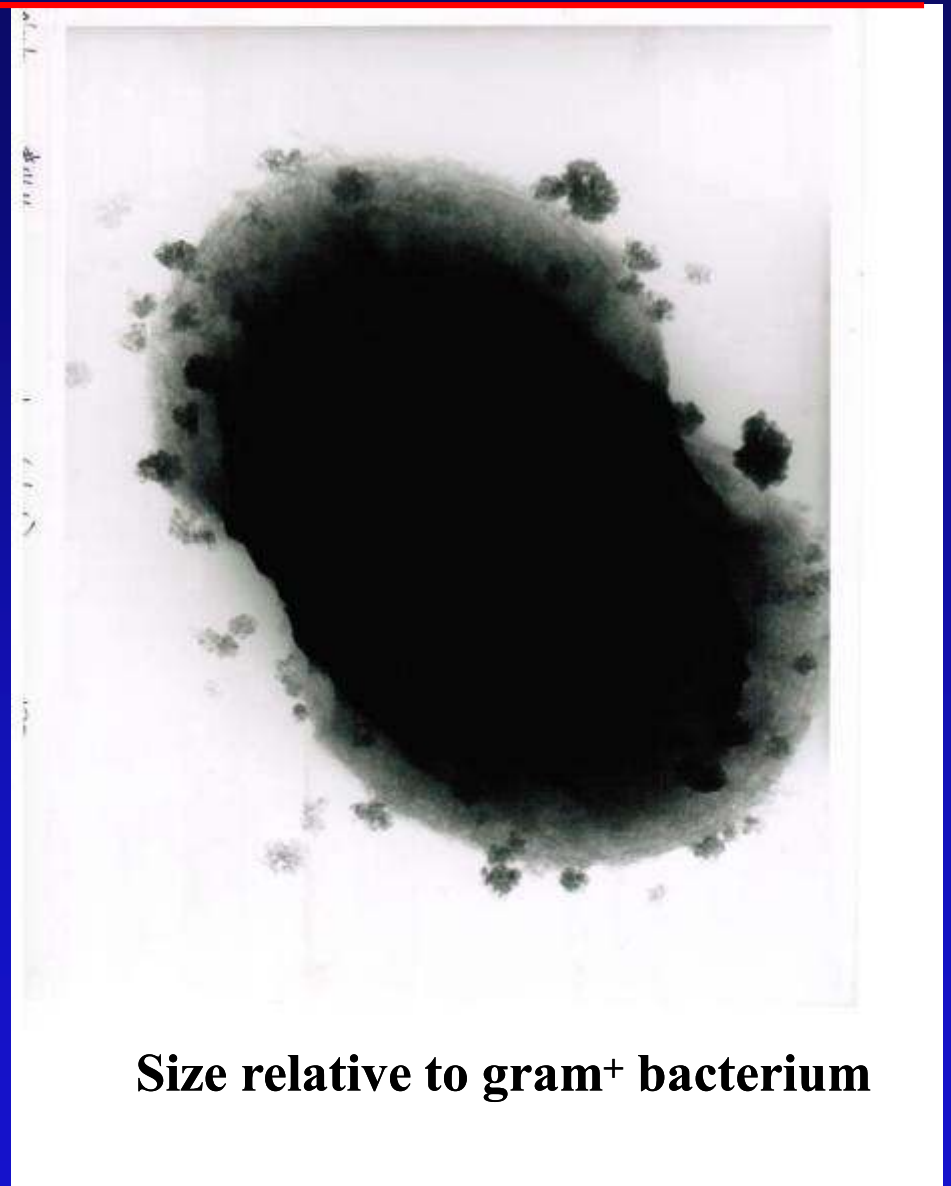


## 'Fungus-like' Growth (transmission EM)



38,250 X magnification

## Size of organism compared with alfa-*Streptococcus*



Size relative to gram<sup>+</sup> bacterium

# Occurrence

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- **Verified in IA, IL, KY, MI, NE, ND, SD, WI**

- **Sources: 'Environmental'**

**Soybean meal**

**Silage**

**Corn grain and silage**

**SDS Soybean plants**

**Manure**

**Soil**

**Animal tissue**

**Placental tissue**

**Amniotic fluid**

**Semen**

**Stomach contents**

**Eggs**

**Milk**

***Fusarium solani fsp glycines* mycelium**

# **Potential Interactions of 'new entity' with Glyphosate**

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- **Glyphosate affects plants (predisposes):**
  - Inhibits plant defenses
  - Reduces nutrient content and efficiency [chemical and RR gene(s)]
  - Increases root colonization
  - Increases membrane permeability
  - Surfactant affect for penetration of natural openings and wounds
- **Glyphosate affects animals (predisposes):**
  - Inhibits aromatase system – endocrine hormone system
  - Toxic to liver, placental, testicular, and kidney cells
  - Reduced defense - liver function [from lower Mn, etc. in feed]
- **Glyphosate affects pathogens:**
  - Stimulates growth and virulence (direct/indirect)
  - Favors synergism, infection (as a carrier)
  - Increases movement into plant tissues (water film for plant infection)
- **Glyphosate affects the environment:**
  - Toxic to soil microbes that constrain plant pathogens
  - Micronutrient availability reduced

# Failure to Honor

## \* Scientific Precautionary Principle

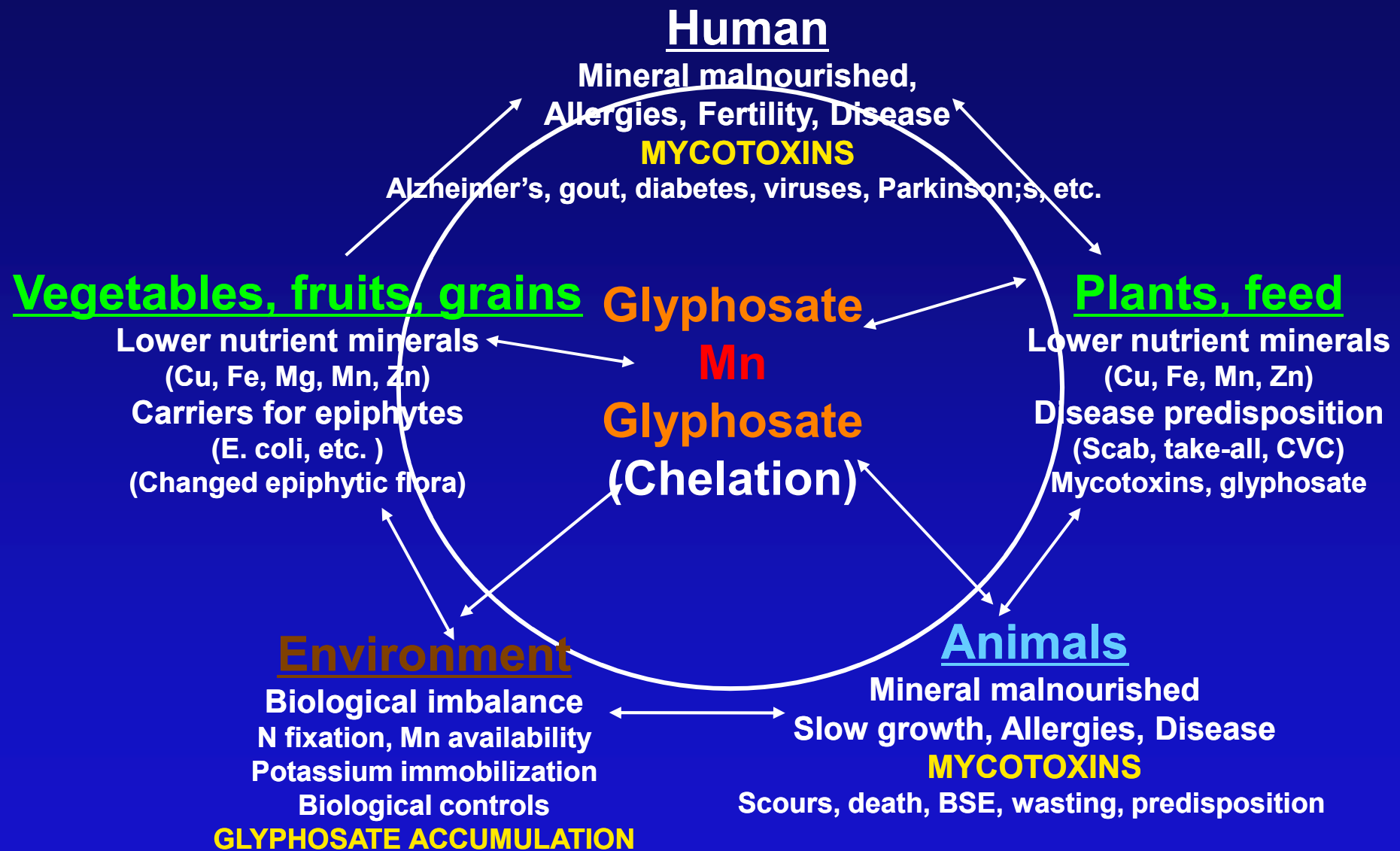
1. Margin of safety to prevent damage
2. Anticipation of unknowns
3. Initiate as a “pilot project”

## \* Not “Substantially Equivalent”- Significant deviation in:

1. Expression of ‘end products’ (new/tissues in)
2. More like virus infection than sexual transfer
3. Functional and regulatory controls absent
4. Greatly extended exposure
5. Production, quality, safety & toxicity differ

After Brown, 2000

# Potential Far-Reaching Impact of Glyphosate



# ***Failed Promises – Touted Benefits***

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- ✓ 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***