

Navigating the Controversies over GMO Crops

The good, the bad, and the
righteous



Steve Strauss
Oregon State University



Why is this so controversial?

- Powerful science – broader gene pool, more efficient, local and global need pressing
- Large corporations – Monsanto effect
- New and strong patents – gene movement in environment
- Industrial agriculture concerns/opposition
 - Herbicide and pesticide use / treadmill
- Environmentalist-local-organic-natural food and health movements – ideologically against all of the above
 - Strong financial motive to oppose-stigmatize-label-ban
- Governments and regulatory regimes in the middle – how to control-regulate-consider given polarization, issues?

Roadmap for talk

- **A bit about me**
- Orientation
 - The context, definition of GE
- The good, bad, and the righteous
 - Good: Status in world, a few examples, humanitarian promise
 - Bad: Mismanagement, regulation/trade
 - Righteous: A la Jonathan Haidt – “Moral certainty” that polarize and impede collaborative solutions

Research: Genetics and genetic engineering of poplars



Outreach: Former Director, OSU Outreach in Biotechnology program for 8 years



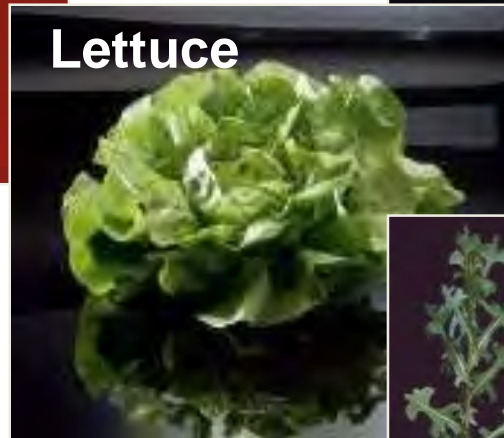
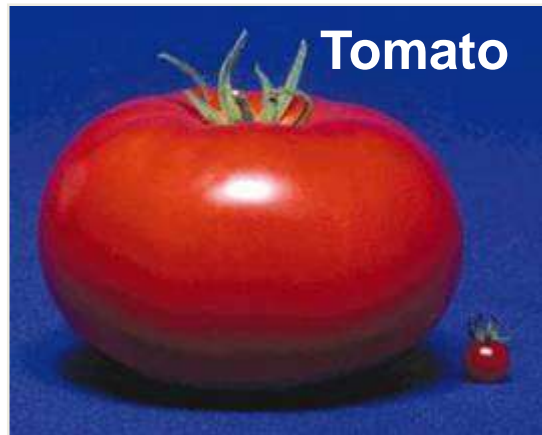
20 years of experience in management of field trials



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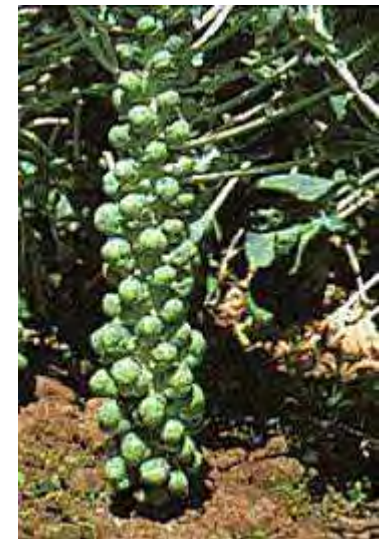
Aren't most food crops already genetically engineered?



Mutants are some of our best friends: Domestication of *Brassica oleracea*



Ornamental kale
Late 1900's



Many plant varieties derived from induced mutations

Over 2,000 crop varieties derived from mutagenesis have been commercialized



Calrose 76 semi-dwarf rice



High oleic sunflower



Rio Red grapefruit

Radical changes in domesticated animals: All dogs derived from the wolf by breeding



Breeding continues and is accelerating in age of massive DNA sequencing



Home / All Products / Live Products / Plant-Indigo Rose Tomato

- Growing Guide
- Dealer Locator
- Territorial Tomato Taste-Off

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THE DRUNKEN BOTANIST PLANT COLLECTION

GIFT CERTIFICATES

VISIT THE STORE

NEWSLETTER SIGNUP

Plant-Indigo Rose Tomato

80 days. Unlike any tomato that we have seen! Indigo Rose is the first high-anthocyanin tomato commercially available anywhere in the world. The high amount of anthocyanin (a naturally occurring pigment that has been shown in high disease in humans) creates quite a vibrant indigo, almost blue skin on the 2 inch, round fruit. The purple coloring occurs on the portion of the fruit that is exposed to light, while the shaded portion starts out green and turns deep red when mature. Inside, the flesh reveals the same rosy tone with a superbly balanced, multifaceted tomatoey flavor. The indeterminate plants have an open habit and are very vigorous producers. Bred at Oregon State University.

Available only within the contiguous US.

[More Live Transplant Information](#)

OP - Open Pollinated

Like 129 Tweet 3 Pin it 47 +1 0 Share

Yet GMOs, and only GMOs, have remained powerfully controversial for ~two decades



Recently passed Oregon bill motivated by anti-GMO activism at county level

77th OREGON LEGISLATIVE ASSEMBLY--2013 Special Session

**Enrolled
Senate Bill 863**

Sponsored by JOINT COMMITTEE ON SPECIAL SESSION

CHAPTER

AN ACT

Relating to preemption of the local regulation of agriculture; and declaring an emergency.

Be It Enacted by the People of the State of Oregon:

SECTION 1. Sections 2 and 3 of this 2013 special session Act are added to and made a part of ORS 633.511 to 633.750.

SECTION 2. (1) As used in this section, "nursery seed" means any propagant of nursery stock as defined in ORS 571.005.

(2) The Legislative Assembly finds and declares that:

(a) The production and use of agricultural seed, flower seed, nursery seed and vegetable seed and products of agricultural seed, flower seed, nursery seed and vegetable seed are of substantial economic benefit to this state;

(b) The economic benefits resulting from agricultural seed, flower seed, nursery seed and vegetable seed and seed product industries in this state make the protection, preservation and promotion of those industries a matter of statewide interest that warrants reserving exclusive regulatory power over agricultural seed, flower seed, nursery seed and vegetable

(c) The agricultural seed, flower seed, nursery seed and vegetable seed and seed product industries in this state will be adversely affected if those industries are subject to a patchwork of local regulations.

SECTION 3. (1) The emergency clause does not apply to this Act.

Jackson County, Oregon GMO ban - on ballot this month

Proposed GMO crop ban in Jackson County attracts opposing farm interests from around country



Vermont labeling law passed

The New York Times



DEALBOOK
Sotheby's and Loeb End
Fight Over Board



Europe Expects Its
Economy to Grow 1.6%
This Year

China Tightens Rules for Foreign-Made
Milk Powders

Pfizer Profit Tumbles 1

BUSINESS DAY

Vermont Will Require Labeling of Genetically Altered Foods

By STEPHANIE STROM APRIL 23, 2014

EMAIL

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SAVE

MORE

Going further than any state so far, Vermont on Wednesday [passed a law](#) requiring the labeling of foods that contain genetically engineered ingredients.

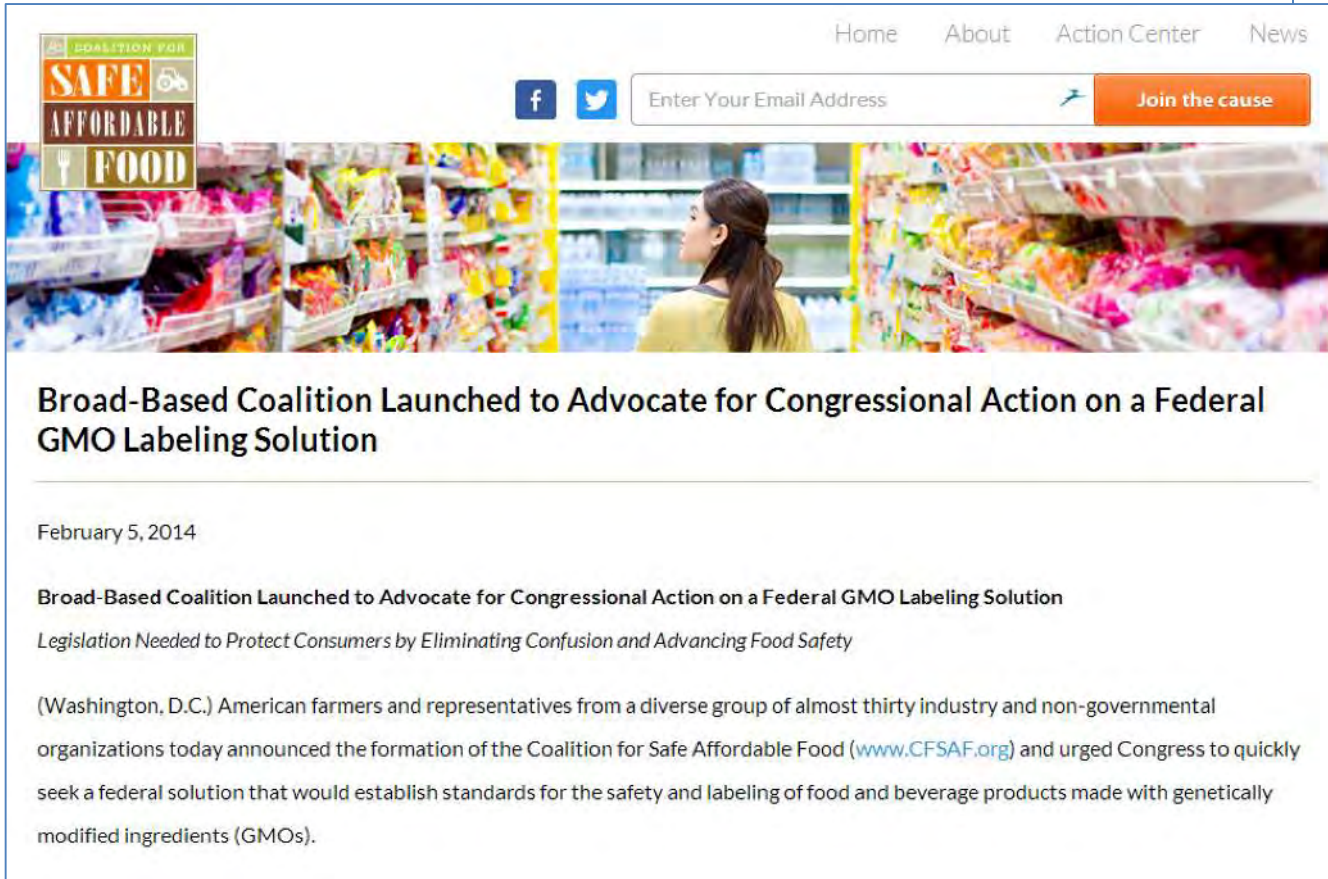
Though the move came in a tiny state far from the nation's population centers, proponents of such labeling immediately hailed the legislative approval as a significant victory. Labeling efforts are underway in some 20 other states, and the biotech and food industries have been pushing for [federal legislation](#) that would pre-empt such action.

BELLE
NOW PLAYING

Effort underway to standardize and prohibit Balkanization of GE regulations throughout USA

- American Bakers Association
- American Beverage Association
- American Farm Bureau Federation
- American Feed Industry Association
- American Frozen Food Institute
- American Seed Trade Association
- American Soybean Association
- American Sugarbeet Growers.....

AND 20 MORE



Home About Action Center News

SAFE AFFORDABLE FOOD

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Broad-Based Coalition Launched to Advocate for Congressional Action on a Federal GMO Labeling Solution

February 5, 2014

Broad-Based Coalition Launched to Advocate for Congressional Action on a Federal GMO Labeling Solution

Legislation Needed to Protect Consumers by Eliminating Confusion and Advancing Food Safety

(Washington, D.C.) American farmers and representatives from a diverse group of almost thirty industry and non-governmental organizations today announced the formation of the Coalition for Safe Affordable Food (www.CFSAF.org) and urged Congress to quickly seek a federal solution that would establish standards for the safety and labeling of food and beverage products made with genetically modified ingredients (GMOs).

Views are polarized

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FEATURE

US public opinion divided over biotechnology?

Although a majority of US citizens remain supportive, opposition to biotechnology is on the rise.

Susanna Hornig Priest

Conventional wisdom judges the people of the United States to have few concerns about biotechnology in comparison to people in other parts of the developed world. According to data from a new survey, this picture is at once both accurate and misleading. At least one other major comparative study using data from 1996–1997 published this year appeared to indicate generally more favorable attitudes in the US than in Europe¹. But recent data reflect mixed opinions in the US consistent with other evidence suggesting moderate declines in US support. While the proportions may be different, the US increasingly resembles Europe in having significant amounts of opposition.

A changing climate

Several reports have suggested that the con-

greater than benefit rose from 20% in 1995 to 24% in 1997 to 29% in 1999². Other indicators suggest US opinion has grown increasingly negative. According to figures released by the US Office of Technology Assessment, in 1986 only 22% of the US public thought genetic engineering would make “the quality of life” worse, and in 1982 only 16%⁴.

In this context, the Public Policy Research Institute at Texas A&M University conducted a telephone survey for the author between April 10 and May 3 that explored current public attitudes to biotechnology. The nationwide survey was limited to US citizens aged 18 and over, and was based on standard random digit dialing procedures, resulting in 1002 completed interviews out of 3182 qualified contacts (a cooperation rate of 31.5%).

sure does not reach the levels of positive responses obtained in this survey for similar questions about other technologies ranging from computers and information technology (with 87.8% expecting improvement), to solar energy (87.7%), telecommunications (82.3%), the Internet (72.1%), and even space exploration (62.2%). Of the technologies included in this study, only nuclear energy (with just 43.0% expecting it to improve life) scored lower. And of all seven technologies, only nuclear energy (with 32.4% expecting it to “make things worse”) was similar to genetic engineering in garnering close to one-third negative responses. In other words, despite different levels of overall support, the two technologies are very similar in the proportion of people who hold the more pessimistic view. The conventional wisdom that says that genetic engineering is non-controversial in the US is difficult to sustain in the light of these figures, as is the assumption that opposition is limited to the extremist “fringe.”



Susanna Hornig Priest is associate professor in the Department of Journalism, Texas A&M University, College Station TX 77843-4111 (susanna@tamu.edu).

NATURE BIOTECHNOLOGY VOL 18 SEPTEMBER 2000

Broad views predict acceptance-rejection


THE CONVERSATION AN AUSTRALIAN BROADCASTER'S TAKE

Home Business + Economy Environment + Energy Health + Medicine Politics + Society **Science + Technology** Election 2013


Custom Topics Explainers IPCC Fifth Assessment Report Election factcheck SBS Overdiagnosis Election 2013 Issues

9 October 2013, 2:25pm AEST


How values affect our attitudes to genetically modified food

AUTHOR
 **Craig Cornock**
Communications Adviser, Corporate Communicator at CSIRO

DISCLOSURE STATEMENT
Craig Cornock undertook the GM research project for the Department of Innovation.



Provides funding as a Founding Partner of The Conversation
0020 80



Our attitudes to genetic modification are based on how we feel about risk, technology and the pace of change. [View Article](#)

As Rod Lamberts reminded us [here recently](#), when it comes to debates on genetically modified (GM) foods, arguing about the validity of the science is about as effective as

Australia - October 2013

Broad attitudes towards science, technology and nature influence consumer attitudes towards GM foods

Pro-science and technology values are a strong predictor of support for GM foods

Not just polarized, but entrenched and tribalized



See also his TED talks

And pervasive online filters of information further entrench

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GOOOOOOOOOOO

Egypt




- Crisis in Egypt
- Protests of 2011
- Lara Logan



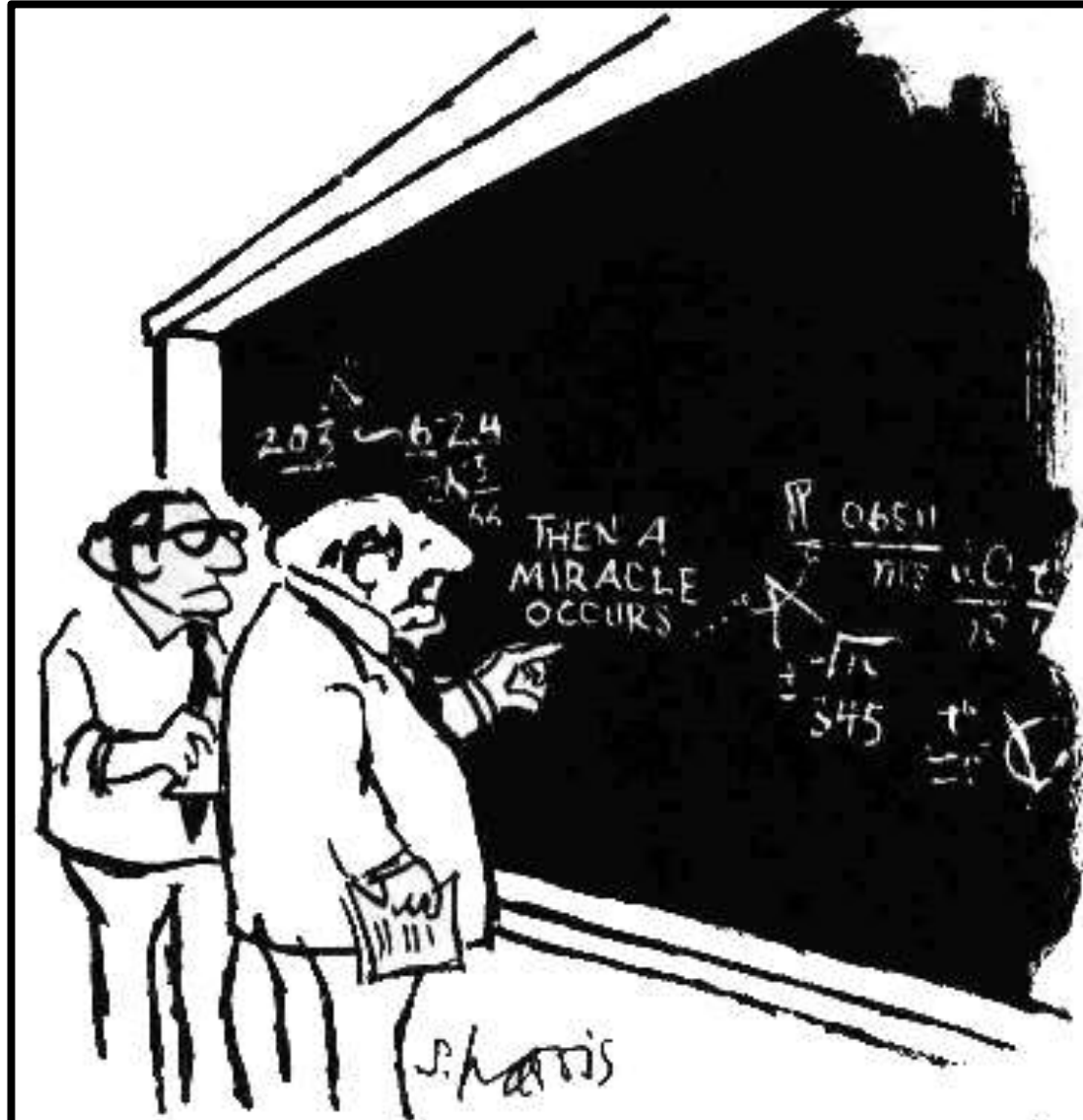
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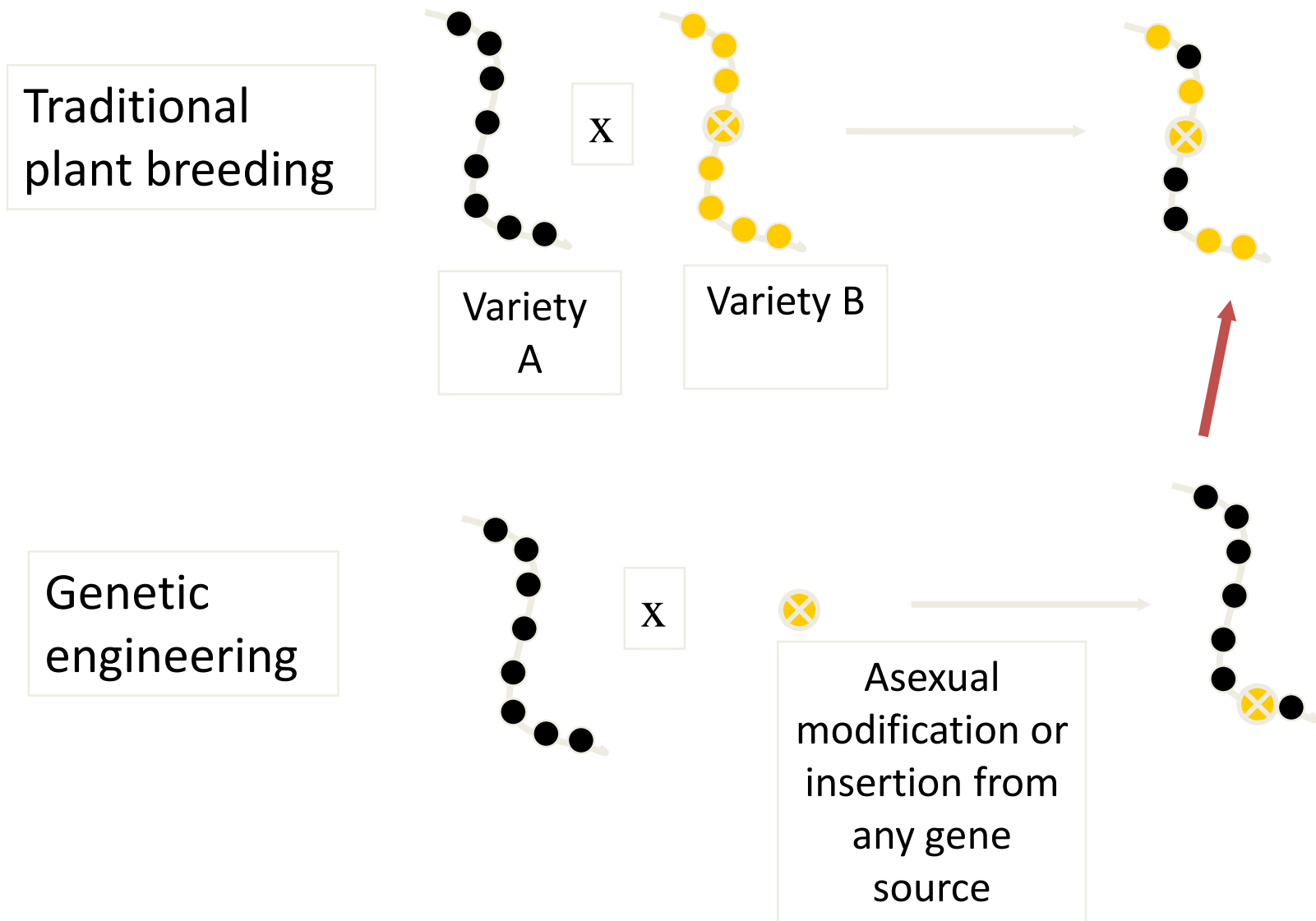
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"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Genetic engineering defined



The GMO acronyms

- **GE (genetic engineering) = GM (genetic modification) = transgenic = asexual modification and/or insertion of DNA**

GMO = genetically modified organism

GEO = genetically engineered organism

The terms “biotechnology” or “modern biotechnology” often equated with GE or GM methods in public media

Then propagated normally (seeds, cuttings) and tested for health and new qualities, incorporated into breeding programs



Propagation of poplars in tissue culture



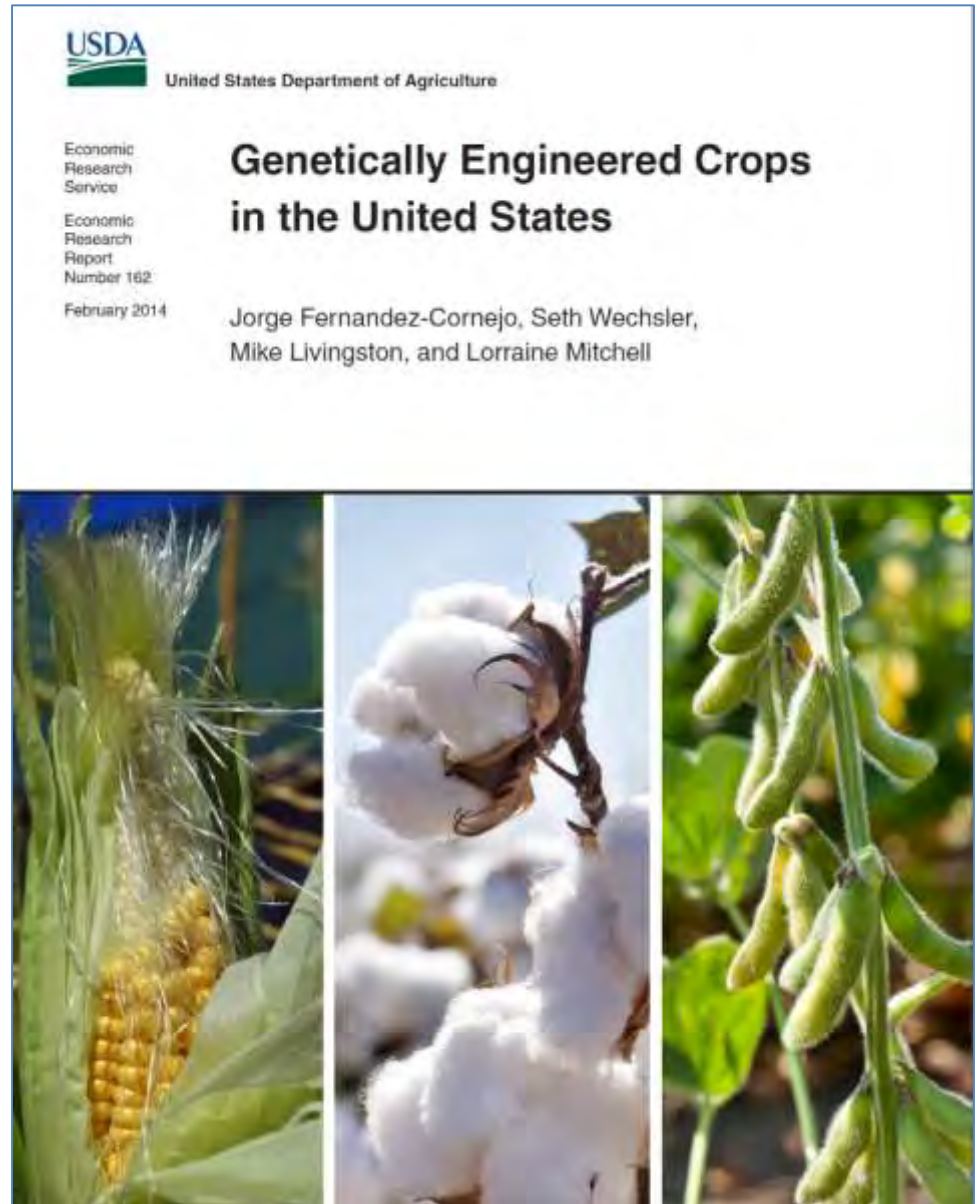
Growth in the field

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The good

Recent USDA report on GE crops in USA – published 2014



<http://www.ers.usda.gov/ersDownloadHandler.ashx?file=/media/1282246/err162.pdf>

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FOR THE ACQUISITION
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/ ISAAA / In Brief

ISAAA in Brief:

- Mission
- Structure and Governance
- Donor Support Groups
- Regional Centers

ISAAA Brochure

- View Flash Paper
- Download PDF (365KB)
- Download ZIP (302KB)

See Also:

- Knowledge Center Brochure
- ISAAA Corporate Video

ISAAA in Brief

Mission

Food, feed, fiber, and fuel for the world's 800 million people who suffer from hunger and poverty – this is the formidable task for many countries, development agencies, and other interest groups. Of the many strategies that have been forwarded to address the issues of global poverty and environmental degradation, crop biotechnology is seen as a viable contribution to the solution. As early as 1991, the International Service for the Acquisition of Agri-biotech Applications (ISAAA) saw the potential of crop biotechnology to improve the lives of small-scale farmers in developing countries. By sharing and disseminating scientific knowledge to the global community, and by facilitating the transfer of technologies to developing countries through public-private partnerships, ISAAA has established its role and contribution in world efforts to help achieve agricultural sustainability and development.

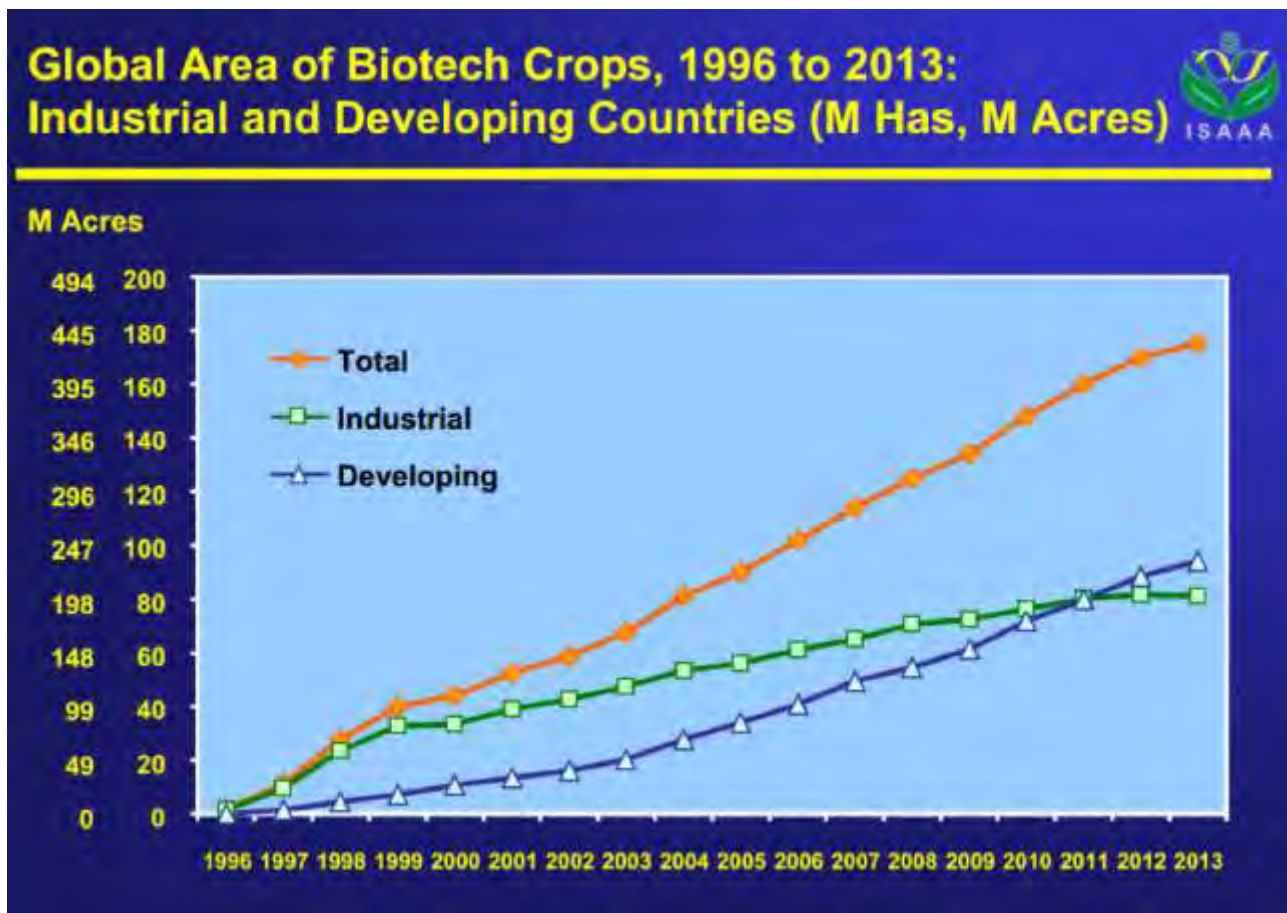
ISAAA's Niche

ISAAA is a not-for-profit international organization that shares the benefits of crop biotechnology to various stakeholders, particularly resource-poor farmers in developing countries, through knowledge sharing initiatives and the transfer and delivery of proprietary biotechnology applications. ISAAA's global knowledge sharing network and partnerships in the research and development continuum,

GMO crops widespread

~Most rapidly adopted innovation in history of agriculture, grown on >10% arable land on planet

* *Extensive uptake in developing world*

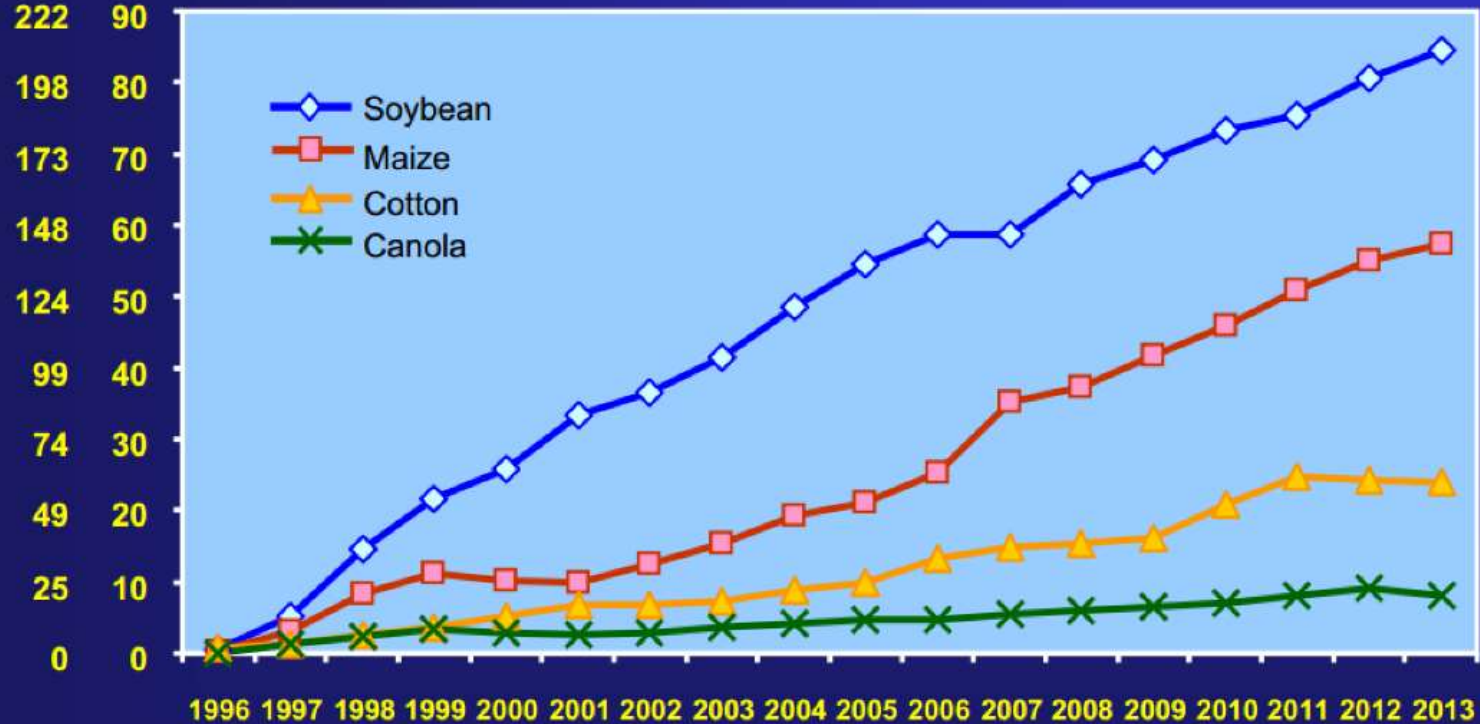


Four crops dominate

Global Area of Biotech Crops, 1996 to 2013: By Crop (Million Hectares, Million Acres)



M Acres

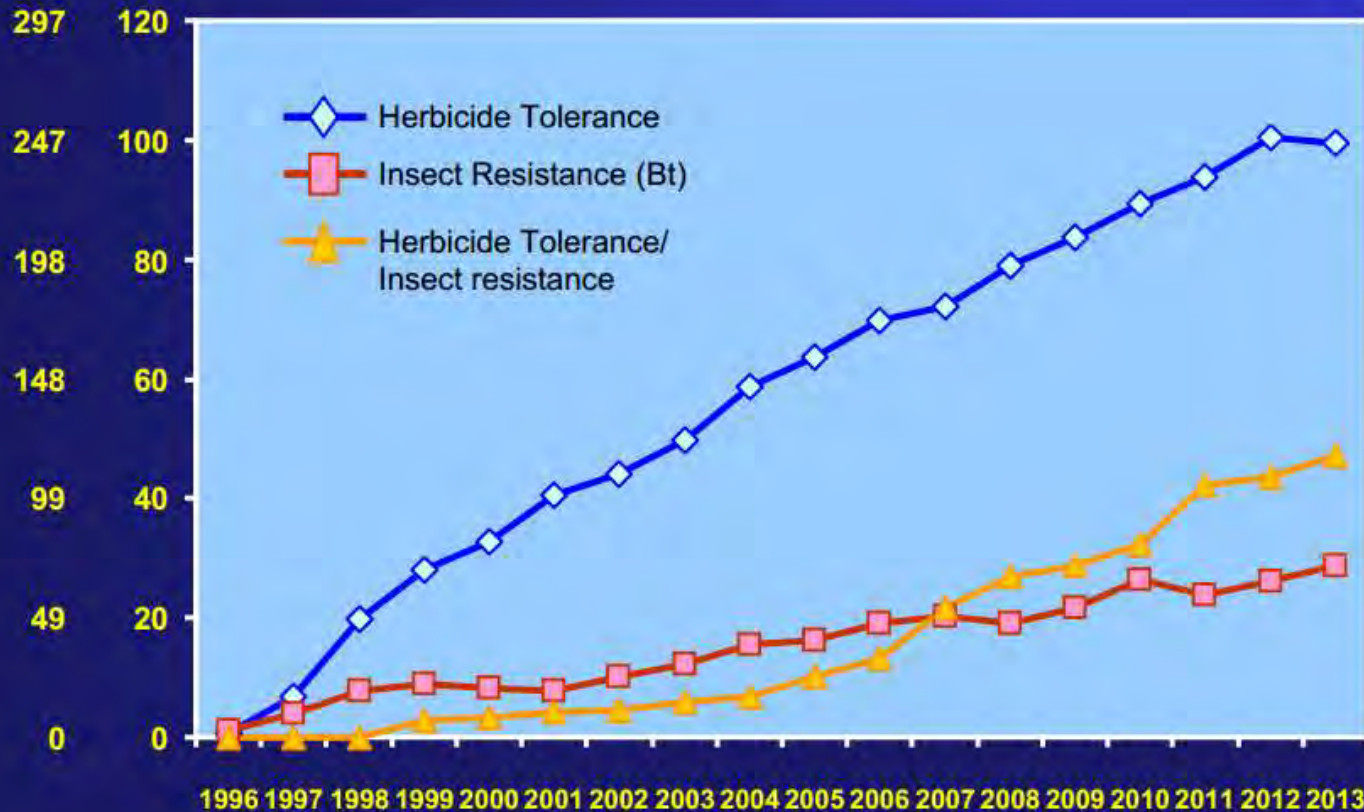


Two traits dominate

Global Area of Biotech Crops, 1996 to 2013: By Trait (Million Hectares, Million Acres)

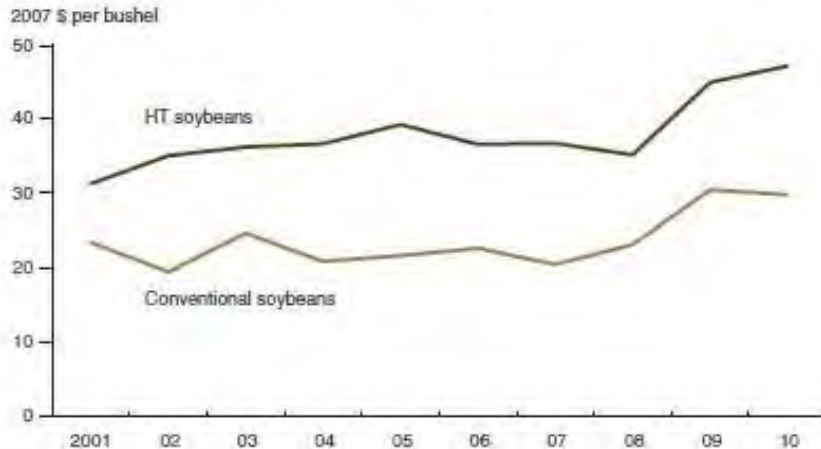


M Acres

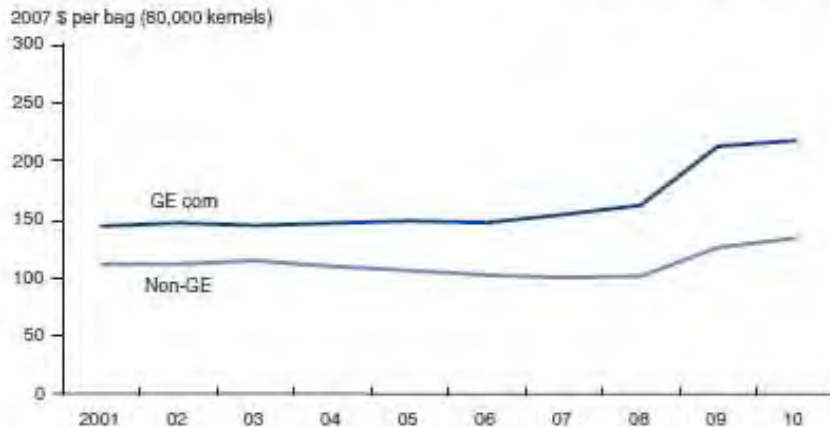


GE seed cost ~50% higher in USA

Figure 11
Prices of genetically engineered (GE) seed are higher than those of non-GE seed, soybeans



Prices of genetically engineered (GE) seed are higher than those of non-GE seed, corn



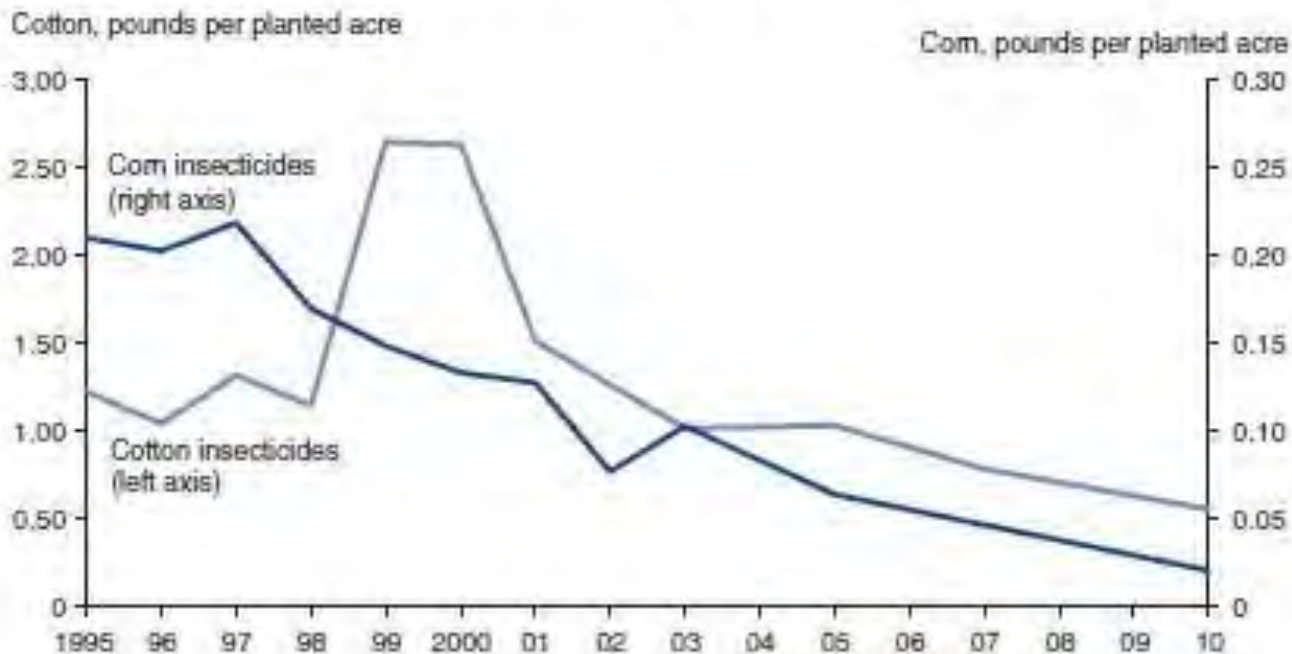
HT crops have herbicide tolerance traits.

Source: USDA Economic Research Service using data from USDA National Agricultural Statistics Service *Agricultural Prices*, various years.

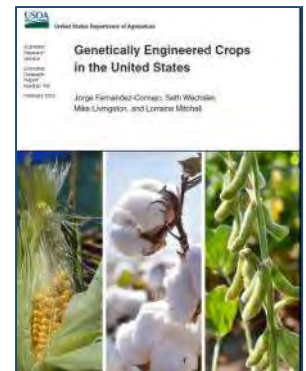


Hundreds of millions of pounds less insecticide use due to GE crops in USA: Maize and cotton

Figure 12
Insecticide use in corn and cotton production, 1995-2010



Source: USDA Economic Research Service using data from USDA National Agricultural Statistics Service Agricultural Chemical Usage reports.



Herbicide tolerant plants promote conservation tillage – With many environmental benefits thereof

Conservation Technology Information Center

- Lowers greenhouse gas emissions
- Improves soil organic matter
- Reduces erosion and fertilizer runoff into water
- Often provides better wildlife habitat



Global: In 2012 reduced CO2 emissions by ~27 billion kg, equivalent to ~13 million cars off the road

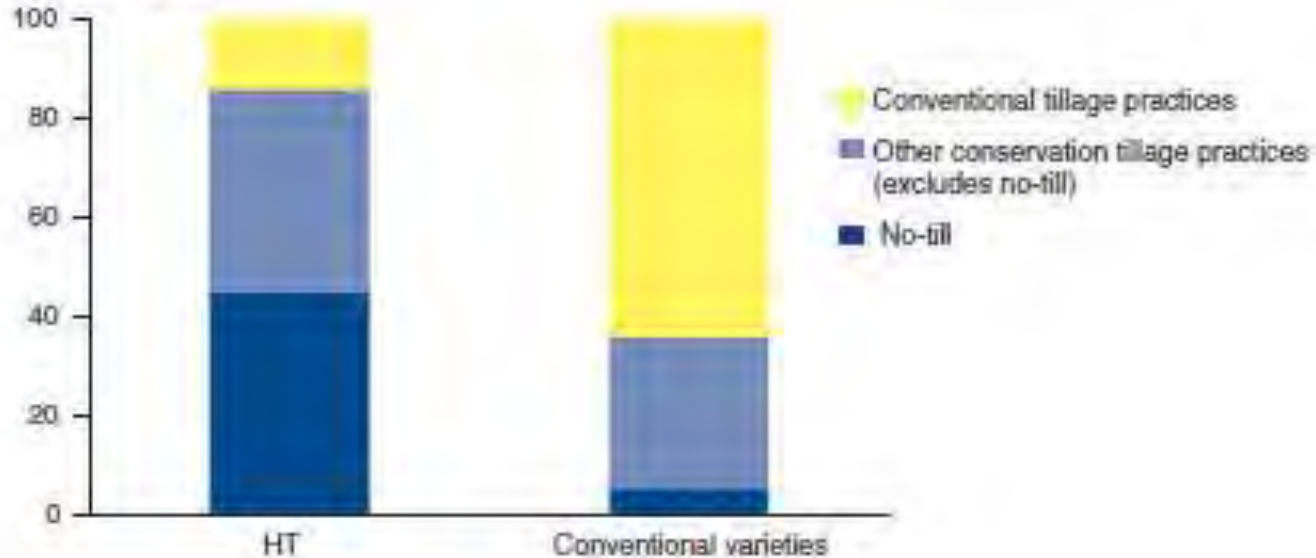
<http://www.isaaa.org/resources/publications/briefs/46/topfacts/default.asp>

Increased conservation tillage due to GE crops in USA: Soy 2006

Figure 15

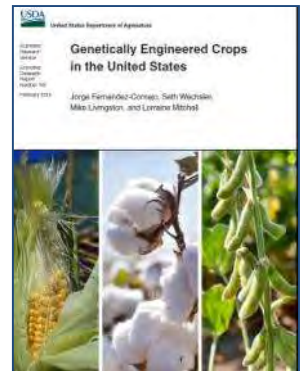
Adopters of herbicide-tolerant crops used conservation tillage more than did growers of conventional varieties: soybeans, 2006

Percent of acres



Conservation tillage includes no-till, ridge-till and mulch-till.

Source: USDA Economic Research Service using data from 2006 ARMS Phase II soybean survey.



Yield benefits significant

Peer-reviewed surveys indicate positive impact of commercialized GM crops

To the Editor:

The benefits of genetically modified (GM) crops continue to be disputed, despite rapid and widespread adoption since their

farmers report yield increases that range from no change for herbicide-tolerant cotton to a 7% increase for herbicide-tolerant soybean and insect-resistant

The results show the variability of benefits from region to region and year to year. A survey of Indian cotton farmers in crop harvest years 2005–2006 through

Table 1 Number and direction of results comparing yields of GM adopters to those of non-adopters, by country

Country	Positive	Neutral	Negative	Total
<i>Developed countries</i>	36	18	7	61
Australia	0	2	2	4
Canada	7	0	1	8
Spain	3	6	0	9
United States	26	10	4	40
<i>Developing countries</i>	88	13	6	107
Argentina	5	1	0	6
China	15	0	0	15
Colombia	4	1	0	5
India	—	—	—	—
Mexico	—	—	—	—
Philippines	—	—	—	—
Romania	—	—	—	—
South Africa	—	—	—	—

Table 2 Average impact on yield, by technology, for developed and developing countries

Technology	Difference in yield (%)	Number of results	Minimum (%)	Maximum (%)	Standard error of the mean (%)
<i>Developed countries</i>	6	59	-12	26	1.0
Herbicide-tolerant cotton	0	6	-12	17	3.8
Herbicide-tolerant soybean	7	14	0	20	1.7
Herbicide-tolerant and insect-resistant cotton	3	2	-3	9	5.8
Insect-resistant corn	4	13	-3	13	1.6
Insect-resistant cotton	7	24	-8	26	1.9
<i>Developing countries</i>	29	107	-25	150	2.9
Herbicide-tolerant corn	85	1	—	—	—
Herbicide-tolerant soybean	21	3	0	35	11
Insect-resistant corn	16	12	0	38	4
Insect-resistant corn (white)	22	9	0	62	6.9
Insect-resistant cotton	30	82	-25	150	3.5

Yield difference for adopters was calculated as (GM yield - conventional yield)/conventional yield, averaging yields across surveys, geographies, years and methodologies. The difference in the number of results reported in Tables 1 and 2 is due to two results reported as 'positive' with no numerical value. A two-tailed *t* test shows a significant difference between the average yields of developed and developing countries ($t = 7.48$, $df = 134$, $P < 0.0005$).

6% mean yield improvement in developed countries

29% in developing countries

Also strong economic, environmental toxicity, and social benefits

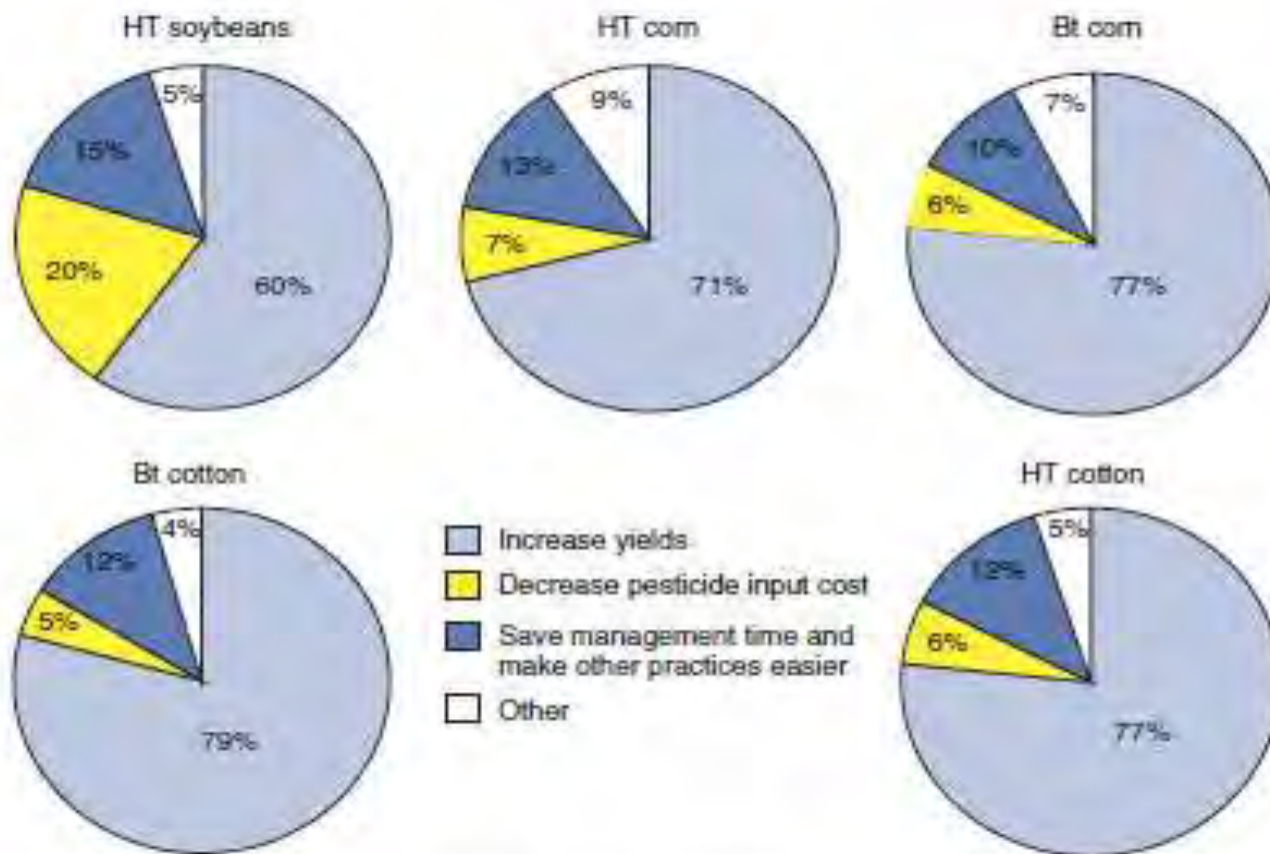
Yield benefits in USA growing with stacked traits: USDA report

“The yield advantage of Bt corn and Bt cotton over conventional seed has become larger in recent years as new Bt traits have been incorporated and stacked traits have become available. Planting Bt cotton and Bt corn continues to be more profitable, as measured by net returns, than planting conventional seeds.”



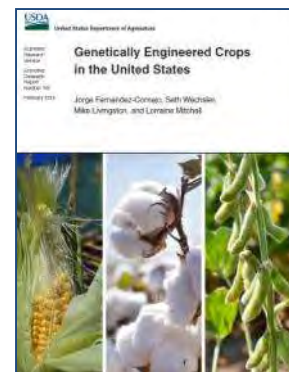
Survey: USA farmers regard yield benefits as a major reason for use of GE crops

Figure 7
Farmers' reasons for adopting genetically engineered crops



Bt crops have insect resistant traits; HT crops have herbicide tolerance traits.

Sources: USDA Economic Research Service using data from Agricultural Resource Management Survey (ARMS) Phase II surveys: 2010 for corn, 2007 for cotton, and 2006 for soybeans.



Benefits provided by biotech crops, on a global scale, large: 1996-2012

- Increased crop production valued at **US\$116.9 billion**
- Conserved biodiversity (indirectly) by saving 123 million hectares of land from 1996-2012
- **Helped alleviate poverty** for >16.5 million small farmers and their families totaling **>65 million people**, who are some of the poorest in the world

Its not all mega-crops or mega-traits

Numerous innovations have been demonstrated in lab or field research, but never make it to market

Below are a few that have or might soon....

Virus-resistant papaya saved the Hawaiian industry in the mid-1990s / ~70% of papaya today

* Nobel prize winning RNAi - “Immunization” via by implanting a viral gene in the papaya genome

* Great humanitarian potential due to wide use of papaya in developing world



Courtesy of Denis Gonsalves, formerly of Cornell University



GMO, virus-resistant trees

Purple GM tomatoes with increased antioxidants and rot resistance

Current Biology 23, 1094–1100, June 17, 2013 ©2013 Elsevier Ltd All rights reserved. <http://dx.doi.org/10.1016/j.cub.2013.04.011>

Anthocyanins Double the Shelf Life of Tomatoes by Delaying Overripening and Reducing Susceptibility to Gray Mold

Yang Zhang,¹ Eugenio Butelli,¹ Rosalba De Stefano,² Henk-Jan Schoonbeek,¹ Andreas Magusin,¹ Chiara Pagliarini,³ Nikolaus Wellner,⁴ Lionel Hill,¹ Diego Orzaez,⁵ Antonio Granell,⁵ Jonathan D.G. Jones,⁶ and Cathie Martin^{1,*}

¹John Innes Centre, Norwich Research Park, Norwich, NR4 7UH, UK

They are produced by plants that disperse [9]. Anthocyanin production is induced under stress conditions [11]. Besides physiological functions, anthocyanins are associated with protection against [12], cardiovascular diseases [13], and cancer [14].



Improved soy oil


Suppression of native gene

HOME PAGE TODAY'S PAPER VIDEO MOST POPULAR U.S. Edition ▼

The New York Times **Business Day**

WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION AI

In a Bean, a Boon to Biotech



DuPont Pioneer's oil compared with soybean oils with partly hydrogenated oils, the source of trans fats.

By ANDREW POLLACK
Published: November 15, 2013

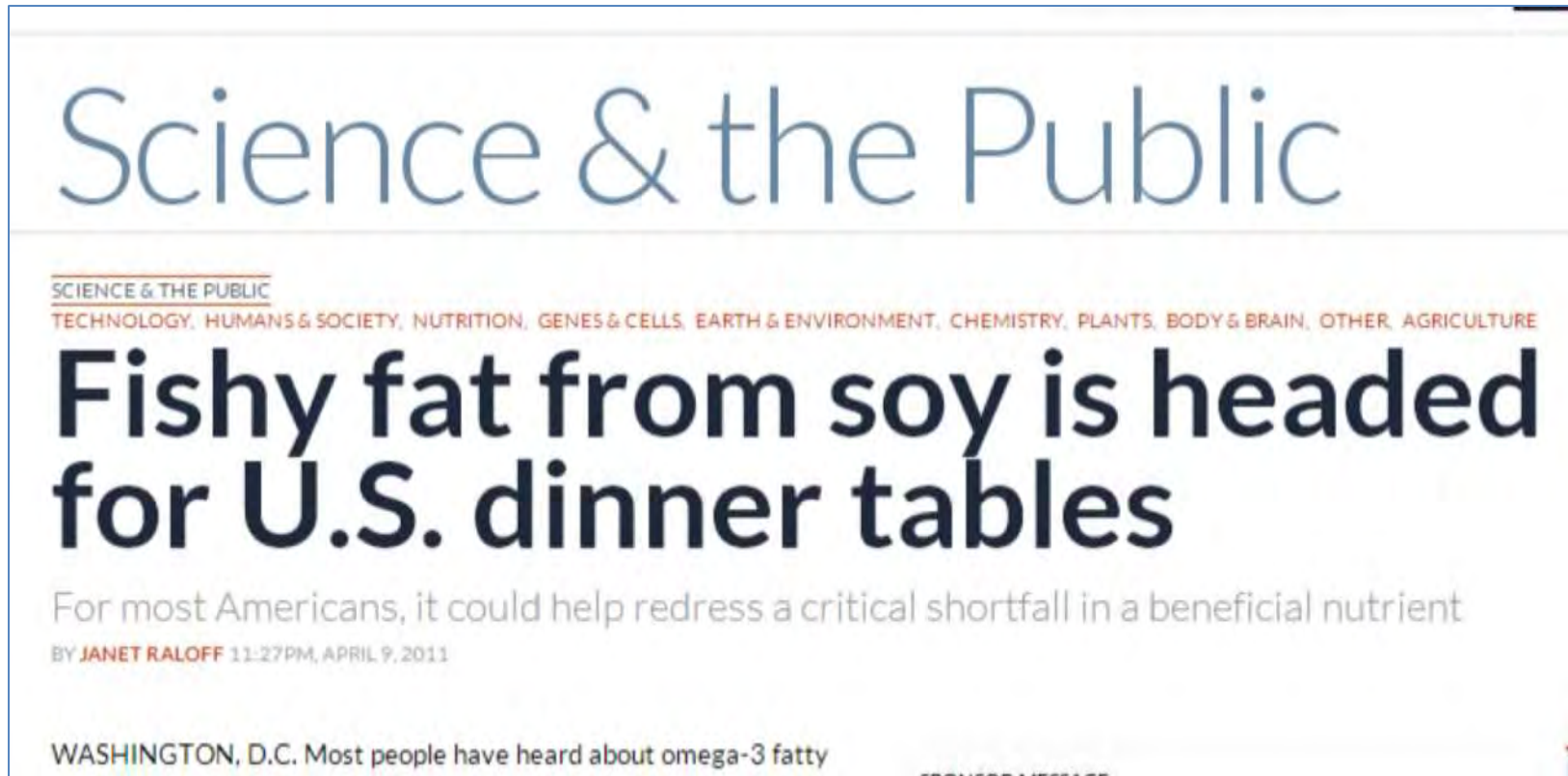
A new federal push to purge artery-clogging trans fats from foods could be just what the doctor ordered — not only for public health but for the unpopular biotechnology industry, specifically, two developers of genetically modified crops.

FACEBOOK
TWITTER
GOOGLE+

“The developers, Monsanto and DuPont Pioneer, have manipulated the genes of the soybean to radically alter the composition of its oil to make it longer-lasting, potentially healthier and free of trans fats.”

“It almost mirrors olive oil in terms of the composition of fatty acids.”

Omega-3 enhanced GM soy oil to promote health, replace fish oils

A screenshot of a news article header from Science & the Public. The title is "Fishy fat from soy is headed for U.S. dinner tables". The author is Janet Raloff, dated April 9, 2011. The article discusses omega-3 fatty acids in GM soy oil.

Science & the Public

SCIENCE & THE PUBLIC
TECHNOLOGY, HUMANS & SOCIETY, NUTRITION, GENES & CELLS, EARTH & ENVIRONMENT, CHEMISTRY, PLANTS, BODY & BRAIN, OTHER, AGRICULTURE

Fishy fat from soy is headed for U.S. dinner tables

For most Americans, it could help redress a critical shortfall in a beneficial nutrient

BY JANET RALOFF 11:27PM, APRIL 9, 2011

WASHINGTON, D.C. Most people have heard about omega-3 fatty

<https://www.sciencenews.org/blog/science-public/fishy-fat-soy-headed-us-dinner-tables>

Potato – reduced browning and acrylamide by gene suppression (↓waste, ↑safety)

Trait #1 - Silenced PPO (Enzyme)

- Non-browning when cut
- Reduced black spot bruise

Trait #2 - Reduced Asparagine (Amino Acid)

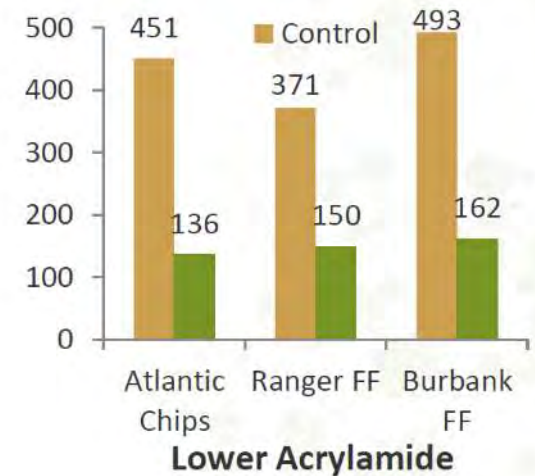
- Yields a 50-80% reduction in acrylamide when baked or fried
- Meets Prop 65 in California

Four Improved Varieties

- Russet Burbank, Ranger Russet, Atlantic, Snowden
- No effect on taste, texture, or performance
- USDA approval expected in 2014

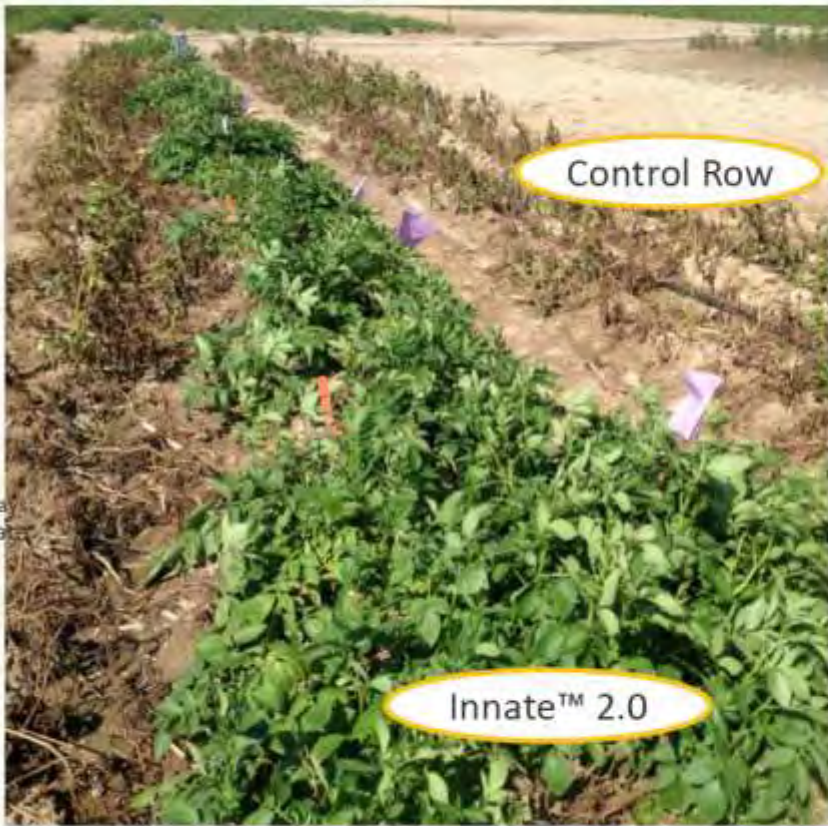


Non-Browning



2nd gen – blight resistant, less sprouting & over-ripening (↓pesticide, ↓waste, ↑yield)

Midwest - Sept 4th 2013



Day
Rate



American Chestnut restoration – genetic engineering a key tool?

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The American Chestnut's Genetic Rebirth

A foreign fungus nearly wiped out North America's once vast chestnut forests. Genetic engineering can revive them

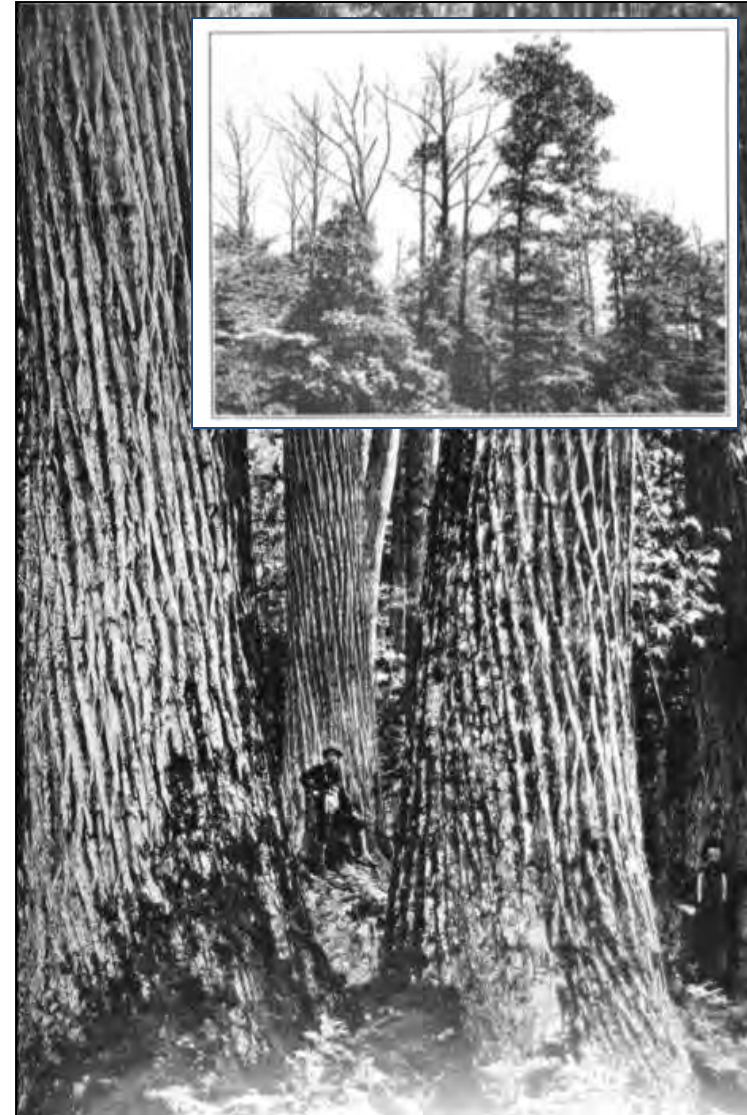
By William Powell

In 1876 Samuel B. Parsons received a shipment of chestnut seeds from Japan and decided to grow and sell the trees to orchards. Unbeknownst to him, his shipment likely harbored a stowaway that caused one of the greatest ecological disasters ever to befall eastern North America. The trees probably concealed spores of a pathogenic fungus, *Cryphonectria parasitica*, to which Asian chestnut trees—but not their American cousins—had evolved resistance. *C. parasitica* effectively strangles

More In This Article

 A New Generation of American Chestnut Trees May Redefine America's Forests

March 2014 issue - Scientific American



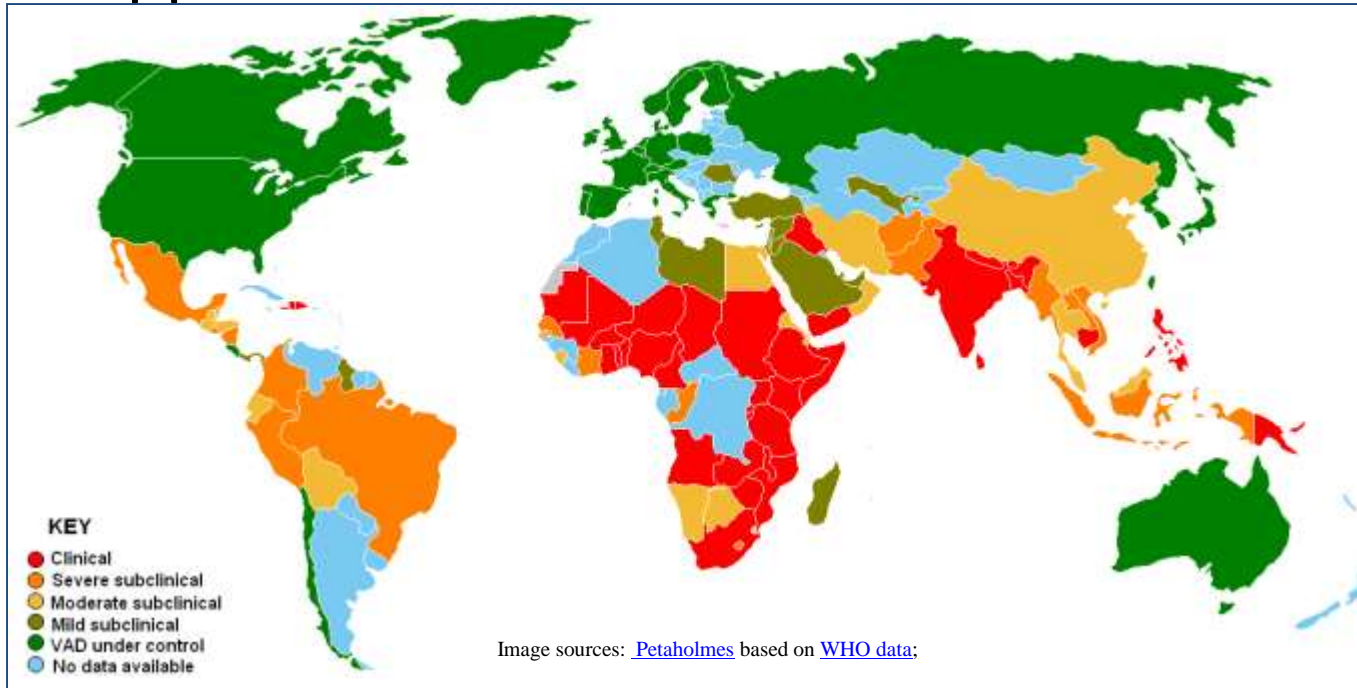
Biofortified plants are improving nutrition for many, and can do much more



The non-profit organization HarvestPlus focuses on the development of biofortified crops for the developing world, including a provitamin A enriched sweet potato that is **currently** being grown by half a million families. Other biofortification projects are underway to increase levels of protein, iron, zinc, antioxidants, and other beneficial components in food.

Why use breeding and biotechnology for β -carotene (pro-vitamin A) enrichment?

Deficiency is widespread, impacts severe, and decades of supplements are unable to overcome



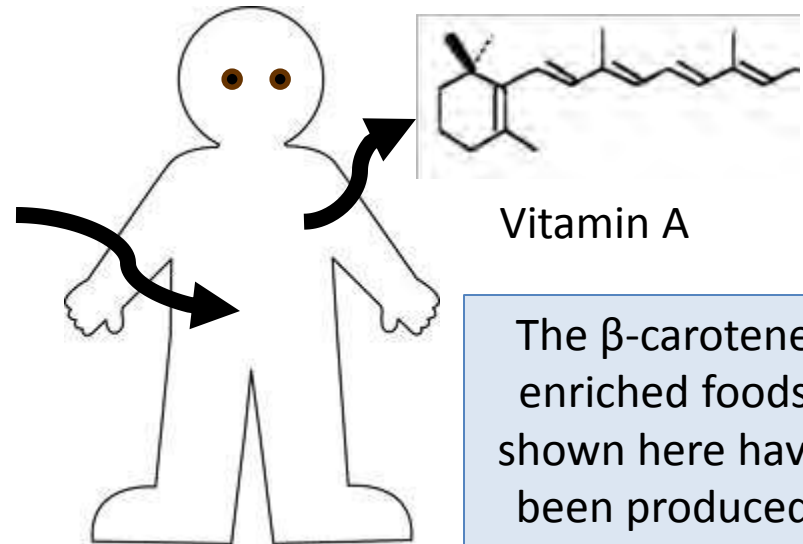
Young women suffering blindness due to Vit A deficiency

Vitamin A deficiency is estimated to affect approximately one third of children under the age of five around the world. It is estimated to claim the lives of 670,000 children under five annually. Approximately 250,000-500,000 children in developing countries become blind each year owing to vitamin A deficiency.... night blindness due to vitamin A deficiency is also high among pregnant women in many developing countries.

Breeding and GMO methods can enhance plant nutritional quality



β -carotene

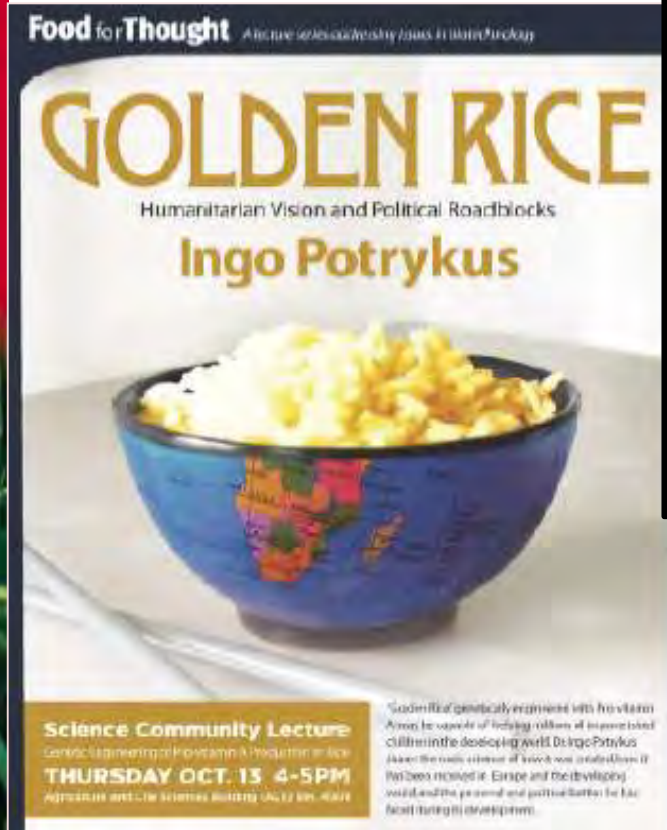
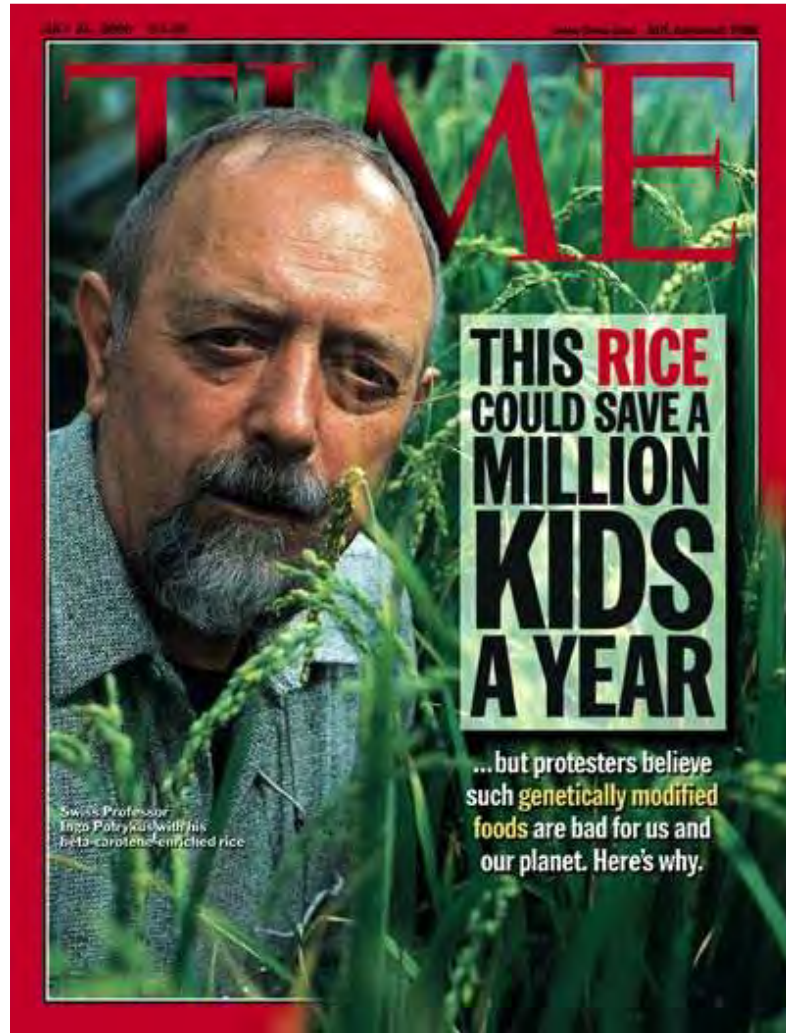


Vitamin A

The β -carotene enriched foods shown here have been produced using GM and non-GM approaches

Golden Rice is the most prominent GMO biofortification product under development

β -carotene makes the rice look golden



Vitamin A enrichment for the poor in Africa?

DuPont reports breakthrough in introducing beta carotene in Sorghum



In Africa, up to half a million children become blind from Vitamin A Deficiency (VAD) with increased risk of cognitive impairment, disease and death from severe infections. Furthermore, nearly 600,000 women die from c..

20 Feb 2014

IOWA, USA: Dupont has achieved a breakthrough in introducing pro-vitamin (beta carotene) into sorghum, a staple food in Africa which is naturally deficient in key nutrients.

This is expected to help improve nutrition for nearly 300 mn people in Africa dependent on Sorghum. DuPont said that the ability to achieve 100 % of the recommended daily allowance of vitamin A in children from Sorghum has never been achieved before.

In Africa, up to half a million children become blind from Vitamin A Deficiency (VAD) with increased risk of cognitive impairment, disease and death from severe infections. Furthermore, nearly 600,000 women die from childbirth-related causes, many from complications that could be reduced through more vitamin A in their diet.

The bad

Poor weed management has led to rapid development of herbicide tolerant weeds

nature biotechnology

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NATURE BIOTECHNOLOGY | NEWS

Glyphosate resistance threatens Roundup hegemony

Emily Waltz

Nature Biotechnology 28, 537-538 (2010) | doi:10.1038/nbt0610-537

Corrected online 13 October 2010

Corrigendum (October, 2010)

PDF Citation Reprints Rights & permissions Article metrics

Weeds are becoming increasingly resistant to glyphosate, a report from the US National Academy of Sciences (NAS) released in April has found. The driving force, according to the report, is farmers' dependence on the weed killer accompanied by the widespread adoption of genetically modified (GM) herbicide-tolerant crops. Seed makers are hoping to forestall the problem by developing GM crops with 'stacked' traits that tolerate multiple herbicides. But weed scientists warn that if farmers manage these new crops in the same way as they managed their glyphosate-tolerant predecessors, weeds will simply become resistant to the new technologies.



"The number of weed species evolving resistance to glyphosate

#ELLIMAYSDALE / #GETOCDGR

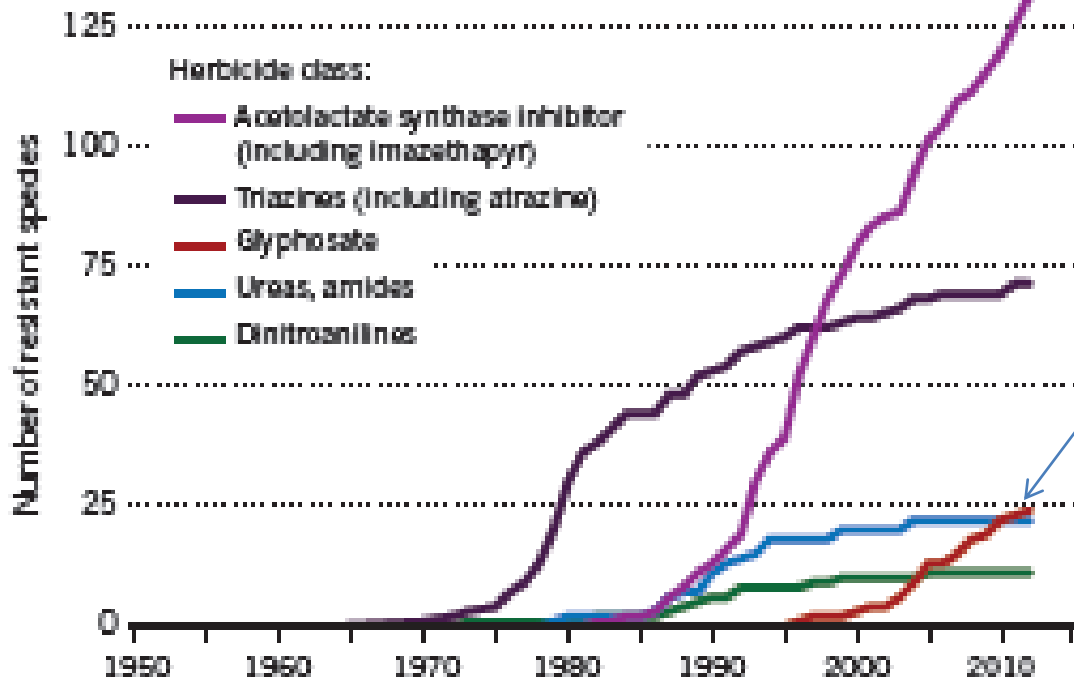


Herbicide-resistant weeds are an old problem in agriculture

THE RISE OF SUPERWEEDS

Weed species often become resistant to herbicides. Glyphosate resistance, once deemed unlikely, rose after genetically engineered crops were introduced in the mid-1990s.

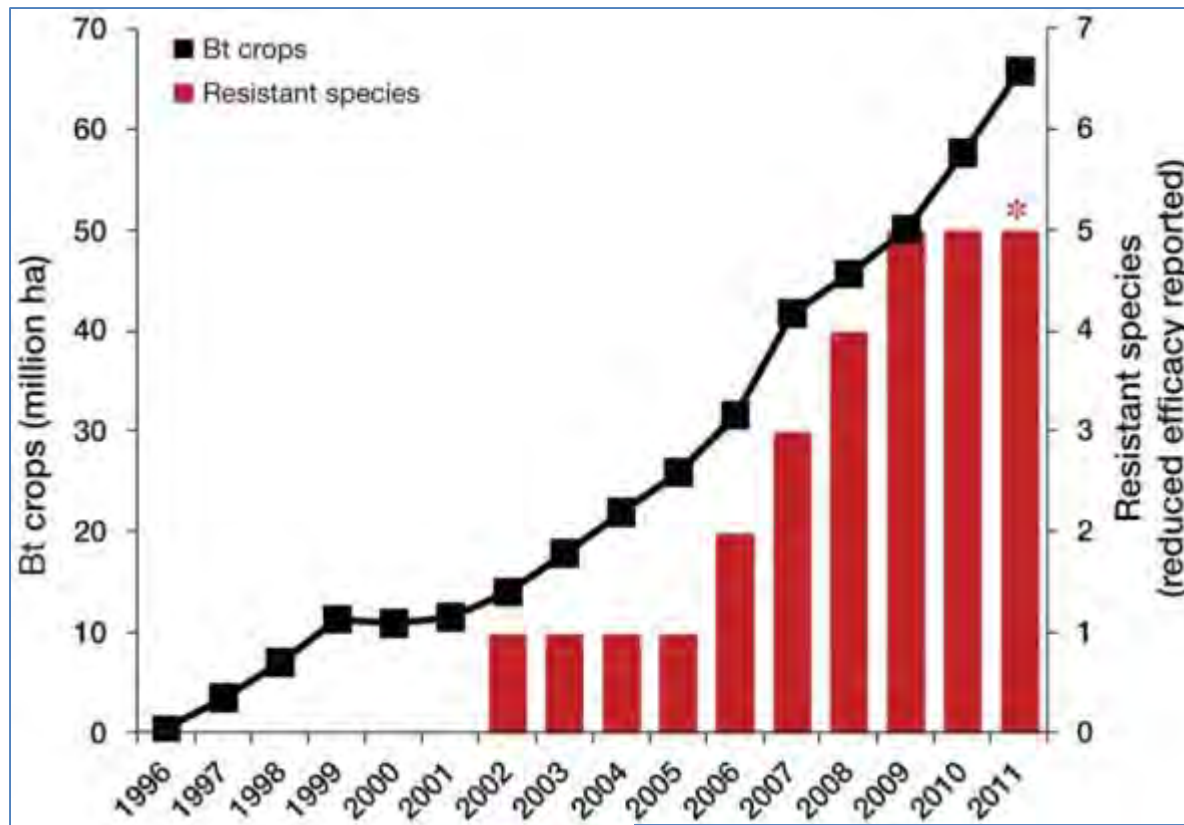
SOURCE: INTERNATIONAL JOURNAL OF HERBICIDE RESISTANT WEEDS WWW.IJHRW.EDU/ISSN/ISSN1546-0092/PAGE/6 (2010).



Accelerated
by GE
Roundup-
tolerant
crops



Insect resistance has developed too, but has been much better managed



[Insect resistance to Bt crops: lessons from the first billion acres](#)
Nature Biotechnology, 31, 510–521 (2013)

Analogous to antibiotics, continued benefits require integrated management, and inputs of new genes/traits

Insecticide resistant crops not new – first noted 100 years ago

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The First Journal Article on Insecticide Resistance was Published 100 Years Ago this Month

April 8, 2014 by Entomology Today LAM & Christophers



The image contains five scientific illustrations labeled A through E. Illustration A shows a fly-like insect with long wings and antennae. Illustration B is a circular diagram of an insect's head or thorax with various internal structures. Illustration C shows a more complex insect, possibly a beetle or a similar species, with detailed anatomical features. Illustration D is a circular, textured structure, possibly a cross-section of an insect's body or a specific organ. Illustration E is a small, dark, oval-shaped object, possibly an egg or a larva.

One hundred years ago this month, an entomologist at the Washington Agricultural Experiment Station named A. L. Melander published an article in the *Journal of Economic Entomology* called "Can Insects Become Resistant to Sprays?" It is widely regarded as the first ever published article on arthropod resistance to insecticides.

Are declines in monarch butterflies-- associated with reduced milkweed populations-- due to improved weed control from herbicide-tolerant crops?



01 APR 2013 | INTERVIEW

Tracking the Causes of Sharp Decline of the Monarch Butterfly

A new census found this winter's population of North American monarch butterflies in Mexico was at the lowest level ever measured. Insect ecologist Orley Taylor talks to Yale Environment 360 about how the planting of genetically modified crops and the resulting use of herbicides has contributed to the monarchs' decline.

BY RICHARD CONNIFF

University of Kansas insect ecologist Orley R. "Chip" Taylor has been observing the fragile populations of monarch butterflies for decades, but he says he has never been more concerned about their future.

Monarchs are beloved for their spectacular migration across Canada and the United States to overwintering sites in central Mexico — and back again. But a new census taken at the monarchs' wintering grounds found their population had declined 59 percent over the previous year and was at the lowest level ever measured.

In an interview with *Yale Environment 360* contributor Richard Conniff, Taylor — founder and director of Monarch Watch, a conservation and outreach program — talked about the factors that have led to the sharp drop in the monarch population. Among them, Taylor said, is the increased planting of genetically modified corn in the U.S. Midwest, which has led to greater use of herbicides, which in turn kills the milkweed that is a prime food source for the butterflies.



Orley Taylor

ABOUT THE AUTHOR

Richard Conniff, who conducted this interview for *Yale Environment 360*, is a National Magazine Award-winning writer whose articles have appeared in *Time*, *Smithsonian*, *The Atlantic*, *National Geographic*, and other publications. He is the author of several books, including *The Species Seekers: Heroes, Fools, and the Mad Pursuit of Life on Earth*. In previous articles for *Yale Environment 360*, he has written about the pricing of ecosystem services and about new advances that could help produce food crops that can thrive as the



RELATED ARTICLES

Into the Heart of Ecuador's Yasuni

*Few places on earth harbor as much biodiversity as Ecuador's Yasuni Biosphere Reserve, which sits atop vast deposits of oil and now faces intense development pressure. In a *Yale Environment 360* video, filmmaker Ryan Killackey travels to the heart of Yasuni with scientists inventorying its stunning wildlife and plants. The researchers hope their work will bolster initiatives to preserve this threatened land.*

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Continued worry over safety of approved GMO food for human health

FEATURE

How safe does transgenic food need to be?

Laura DeFrancesco

Disputes over how to assess a foodstuff's safety continue to play into public fears about transgenic crops.

Transgenic crops are the most highly regulated foods in the world. In recent years, there have been calls in the United States to relax some of the rules for their oversight. And yet controversies over the safety of transgenic food products continue to rumble, particularly in Europe, Africa and now further afield in the Far East. Despite the fact that numerous national and international scientific panels have concluded that food derived through transgenic approaches is as safe as food produced in other ways and that food-borne pathogens pose a much greater threat to human health¹, scare stories continue to

any finished food placed on the market meets the safety levels implicit in the definition of adulterated foods. FDA is authorized to seek sanctions against foods that do not adhere to these standards through seizure, injunction or criminal prosecution," writes Emily Marden of the University of British Columbia's Faculty of Law in Vancouver³. This holds for all new foods, whether transgenic or not.

Notwithstanding the absence of legal underpinnings, a *de facto* regulatory process (called a consultation) exists at the FDA, whereby companies submit information on new genetically modified foods destined for the market



Laura DeFrancesco is Senior Editor at Nature Biotechnology.

Regulation of Biotechnology was laid out (51 Fed. Reg. 23302, June 26, 1986)⁵. Depending on the exact nature of the change made to

Nutrition that is responsible for oversight of the safety of food derived from transgenic crops destined for human consumption.

Very weak
science in a
number of
highly
publicized
GMO
toxicity
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Study linking GM maize to rat tumours is retracted

Publisher withdraws paper despite authors' objections, citing weak evidence.

Barbara Casassus

28 November 2013

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Hundreds of scientific studies of GM crop food and environmental safety

**Critical Reviews
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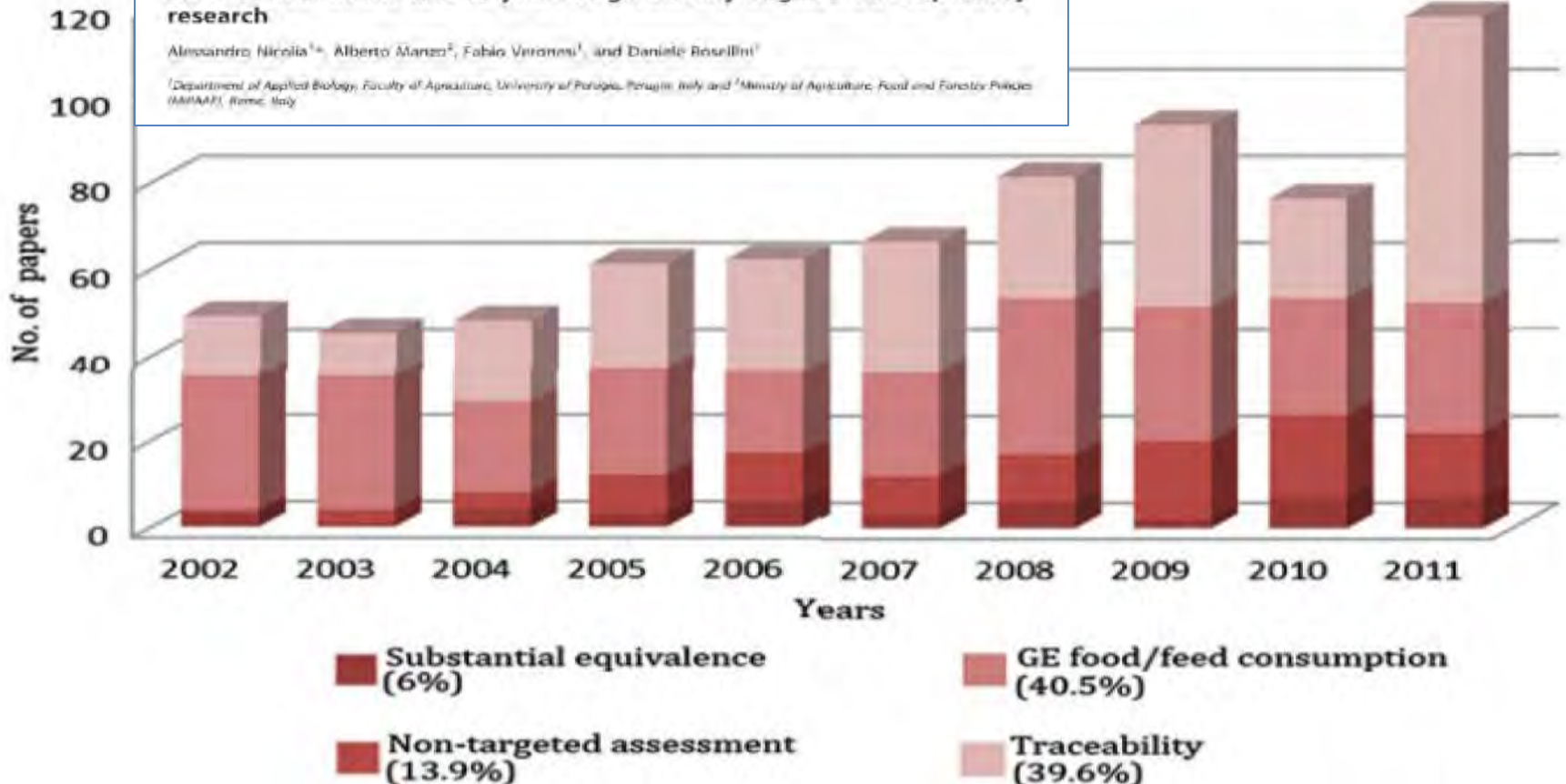
REVIEW ARTICLE

An overview of the last 10 years of genetically engineered crop safety research

Alessandro Nicolai^{1*}, Alberto Marzà², Fabio Verronesi¹, and Daniele Rosellini¹

¹Department of Applied Biology, Faculty of Agriculture, University of Perugia, Perugia, Italy and ²Ministry of Agriculture, Food and Forestry Policies (MIPAF), Rome, Italy

GE crop safety research 5



Overwhelming conclusion of food/feed safety

“The experimental data collected so far on authorized GE crops can be summarized as follows: (a) there is no scientific evidence of toxic or allergenic effects.....”

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Lit Rev Biotechnol, Early Online 1–12
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Is GM food safe?

if an overwhelming majority of experts say something is true, then any sensible non-expert should assume that they are probably right

AAAS
AMA
WHO
European Commission
ACSH
Crop Science Society of America
CAST
FAS
SOT
ICSU

Is GM food safe?

if an overwhelming majority of experts say something is true, then any sensible non-expert should assume that they are probably right



The American Association for the Advancement of Science is an international non-profit organization. AAAS serves some 261 affiliated societies and academies of science.

"The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe."



The National Academy of Sciences is a non-profit organization in the United States. It is the premier scientific body in the United States.

"To date more than 98 million acres of genetically modified crops have been grown worldwide. No evidence of human health problems associated with the ingestion of these crops or resulting food products have been identified"



The premier body of physicians in the United States

"There is no scientific justification for special labeling of genetically modified foods.

Bioengineered foods have been consumed for close to 20 years, and during that time, no overt consequences on human health have been reported and/or substantiated in the peer-reviewed literature."



England's top medical society, the Royal Society of Medicine is an independent educational organisation for doctors, dentists, scientists and others involved in medicine and health care

"Foods derived from GM crops have been consumed by hundreds of millions of people across the world for more than 15 years, with no reported"



The World Health Organization (WHO) is the directing and coordinating authority for health within the United Nations system.

"No effects on human health have been shown as a result of the consumption of GM foods by the general population in the countries where they have been approved.



The European Commission (EC) is the executive body of the European Union

"The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are no more risky than e.g. conventional plant breeding technologies."

<http://www.axismundionline.com/blog/the-new-is-gm-food-safe-meme/>

The scientific consensus around the safety of genetically modified foods is as strong as the scientific consensus around climate change. These foods are subjected to more testing than any other, and everything tells us that they're safe.

Hundreds of scientific studies of glyphosate (active ingredient – Roundup)

Regulatory Toxicology and Pharmacology **31**, 117–165 (2000)

doi:10.1006/rtph.1999.1371, available online at <http://www.idealibrary.com> on IDEAL[®]

Safety Evaluation and Risk Assessment of the Herbicide Roundup¹ and Its Active Ingredient, Glyphosate, for Humans

Gary M. Williams,* Robert Kroes,† and Ian C. Munro‡²

**Department of Pathology, New York Medical College, Valhalla, New York 10595; †RITOX, Universiteit Utrecht, P.O. Box 80176, NL-3508 TD Utrecht Yalelaan 2, The Netherlands; and ‡Cantox Health Sciences International, 2233 Argentia Road, Suite 308, Mississauga, Ontario L5N 2X7, Canada*

Received December 6, 1999

Reviews on the safety of glyphosate and Roundup herbicide that have been conducted by several regulatory agencies and scientific institutions worldwide have concluded that there is no indication of any human health concern. Nevertheless, questions regarding their safety are periodically raised. This review was undertaken to produce a current and comprehensive safety evaluation and risk assessment for hu-

diverse parameters in two multigeneration reproduction studies with glyphosate. Likewise there were no adverse effects in reproductive tissues from animals treated with glyphosate, AMPA, or POEA in chronic and/or subchronic studies. Results from standard studies with these materials also failed to show any effects indicative of endocrine modulation. Therefore, it is concluded that the use of Roundup herbicide does not result in adverse effects on development, repro-

Overwhelming conclusion of human safety

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Prof Parrott / GMO crop information and misinformation web page

tinyurl.com/GMLinks

The GMO Crop (*mis*)Information Page

Providing centralized information resources on GMO crops. Updated 12 December 2013.



Featured Websites:

- [GMO Database](#) - comprehensive information on GMOs
- [BioEconomics](#) - information on environmental impact & economics of GMOs
- [A litmus test of GM food safety research](#)
 - "The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are not any more risky than e.g. conventional plant breeding technologies."

Statistics & Databases:

- [Center for Environmental Risk Assessment](#): A database of all deregulated GM crops & their safety documentation
- [ISAAA - Global statistics of GMO crops](#)
- [Information Systems for Biotechnology](#): Field trials and crop approvals for the USA
- [Biosafety Clearing House](#) - Global list of approved living GMOs

Blogs, News & Commentaries:

- [Biofortified](#)
- [Illumination](#), by Kevin Folta
- [Scoop It - Ag Biotech News](#) by A.J. Stein
- [Tomorrow's Table](#)
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- [Keith Kloor](#) at SLATE
- [United Soybean Board on Biotech](#)
- [Genetic Literacy Project](#)
- [GMO Mondays](#)
- [GM news](#), by SciDevNet

Resources for Educators:

- [Introduction to Biotechnology](#), Ray Herren
- [GMO Crop Photo Depot](#)
- [DNA Ahead Game & More](#)

Refereed Literature Compend

- [Feeding transgenic crops to livestock](#)
- [Transgenic DNA and protein and animal products \(meat, milk, eggs\)](#)
- [GENERA](#) - Refereed safety literature, with safety in the process of being written
- [GMO Pundit](#) - 600+ published assessments of GM foods and feeds
- [ChileBio](#) - A list of 600+ published assessments of GM foods and feeds: refereed articles only

US Food & Drug Administration

- [Role](#)
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- [Guidance to Industry](#)

Authorities endorsing GM safety and use:

- [List of authorities](#), by Axis Mundi
- [Links to position statements](#), by ChileBio
- [Statement by the Pontifical Academy of Sciences](#), Vatican City

FAQs and Answers on Safety

- Free eBook: [The Lowdown on GMOs, According to Science](#) i.e., [A Layman's Guide to GMOs](#)
- [Health Canada](#)

Professor Parrott
singles out some GMO articles that earn a fail!

Because the peer review system is not perfect and some articles that shouldn't get through and because you know how tedious a read

For more details, see the [GMO \(mis\)information Page and Assessment System](#)

GMO-fed pigs have irritated stomachs and thicker uteruses

[Source](#): Cameron JA, Hill J, Meyer LJ, et al. *Journal of Animal Science*. 2012. A long-term toxicology study on pigs fed a combined genetically modified (GM) diet. *Journal of Animal Science* 115: 20-34.

[Why do this article?](#)

GMO corn gives rats cancer

[Source](#): Nishikawa SE, E. Clair, A. Marquis, S. Oishi, N. DeGrazia, M. Mouton, D. Hennigsen, W. Dennis. 2012. Long term toxicity of a Roundup herbicide and a Roundup-tolerant genotype. *Food and Chemical Toxicology* 50:4221-4231.

[Why do this article?](#)

93% of pregnant women and 69% of non-pregnant women to derived Bt protein in their blood

[Source](#): Alik A, S. Lelovici. 2011. Maternal and fetal exposure to pesticides associated to genetically modified (GM) corn. *Canada Reproductive Toxicology* 15: 229-33.

[Why do this article?](#)

GMO corn kills monarch butterflies

[Source](#): Losey JF, LT Rayor, ME Carter. 1999. Transgenic pollen harms monarch larvae. *Nature*

[Why do this article?](#)

GMOs cause intestinal issues in rats

[Source](#): Frew SJ, A. Fuchs. 1994. Effect of feed containing genetically modified potatoes on weanling rats and their mothers. *Journal of Animal Science* 79:1301-1314.

[Why do this article?](#)

The righteous

Corporate hyperbole

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Our Commitment to Sustainable Agriculture

Producing More. Conserving More. Improving Lives.

Our vision for sustainable agriculture strives to meet the needs of a growing population, to protect and preserve this planet we all call home, and to help improve farmers' lives by 2030. We have made a commitment to sustainable agriculture – pledging to improve farmers' lives by 2030.

PRODUCING MORE

Monsanto works with farmers from around the world to make agriculture more sustainable. Our technologies enable farmers to get more from their land.

Specifically, we are working to double yields in our core crops. This will come from a combination of [advanced plant breeding](#), [biotechnology](#), and [improved farm-management practices](#).

CONSERVING MORE

We've strengthened our goal of double crop yields by conserving [resources such as land, water, and energy per unit produced](#).

We're continuing to develop better seeds and improved on-farm practices to better manage weeds, pests, and environmental stresses.

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Glyphosate resistance threatens Roundup hegemony

Emily Waltz

Nature Biotechnology 28, 537–538 (2010) | doi:10.1038/nbt0610-537

Corrected online 13 October 2010

Corrigendum (October, 2010)

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"The number of weed species evolving resistance to glyphosate

#ELLIMINATEDALE / #GETTOGETHER

Confirmed Glyphosate Resistant Weeds in the U.S.



- Horseweed (Marestail)
- Common Ragweed
- Giant Ragweed
- Palmer Amaranth
- Common Waterhemp
- Hairy Fleabane

- Italian Ryegrass
- Rigid Ryegrass
- Johnsongrass

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Left vs. right senses of justice, social systems, roles for corporations, a major reason for outrage

- Profit vs. public good
- Socialist vs. capitalist
- Global vs. local food
- Monsanto vs. small farmers
- Patents vs. open source
- **Major reason for US vs. EU schism**



Are organically certified crops so “righteous” to warrant purity?



Gene flow is ubiquitous in agriculture – with or without GMOs



“Genetic drift” (i.e., seed and pollen movement) does not entitle Monsanto to take over your farm – nor do they try to!

Organic nor conventional is ideal: Coexistence needed



04
SEP

Organic farms not necessarily better for environment

Science
04 Sep 12



Organic cereals generate higher greenhouse gas emissions per unit of product than their conventionally farmed counterparts, the researchers found.

Organic farming is generally good for wildlife but environmental impacts than conventional farming, scientists has shown.



Education Research Patient Care Community

Stanford Medicine > School of Medicine > News > Inside Stanford Medicine

SEPT. 5, 2012

Little evidence of health benefits from organic foods, Stanford study finds

BY MICHELLE BRANDET

You're in the supermarket eyeing a basket of sweet, juicy plums. You reach for the conventionally grown stone fruit, then decide to spring the extra \$1/pound for its organic cousin. You figure you've just made the healthier decision by choosing the organic product — but new findings from Stanford University cast some doubt on your thinking.

"There isn't much difference between organic and conventional foods, if you're an adult and making a decision based solely on your health," said [Dora Bravata, MD, MS](#), the senior author of a paper comparing the nutrition of organic and non-organic foods, published in the Sept. 4 issue of *Annals of Internal Medicine*.

A team led by Bravata, a senior affiliate with Stanford's [Center for Health Policy and Crystal Smith-Spangler, MD, MS](#), an instructor in the school's Division of General Medical Disciplines and a physician investigator at [VA Palo Alto Health Care System](#), did the most comprehensive meta-analysis to date of



Michelle von der Grinten

Crystal Smith-Spangler and her colleagues reviewed many of the studies comparing organic and conventionally grown food, and found little evidence that organic foods are more nutritious.



About Human Agriculture Policy Genes Resources Browse

The organic hepatitis outbreak: We need organic field testing

Mischa Popoff | June 17, 2013 | Genetic Literacy Project

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Today's organic consumer is well informed. They have made the connection between quality of life and their own personal responsibility as for how it's going to play out for them. They understand the risks – the effects of



May have become ill after eating organic, from berries (CREDIT: Flickr/Bob-Weir)

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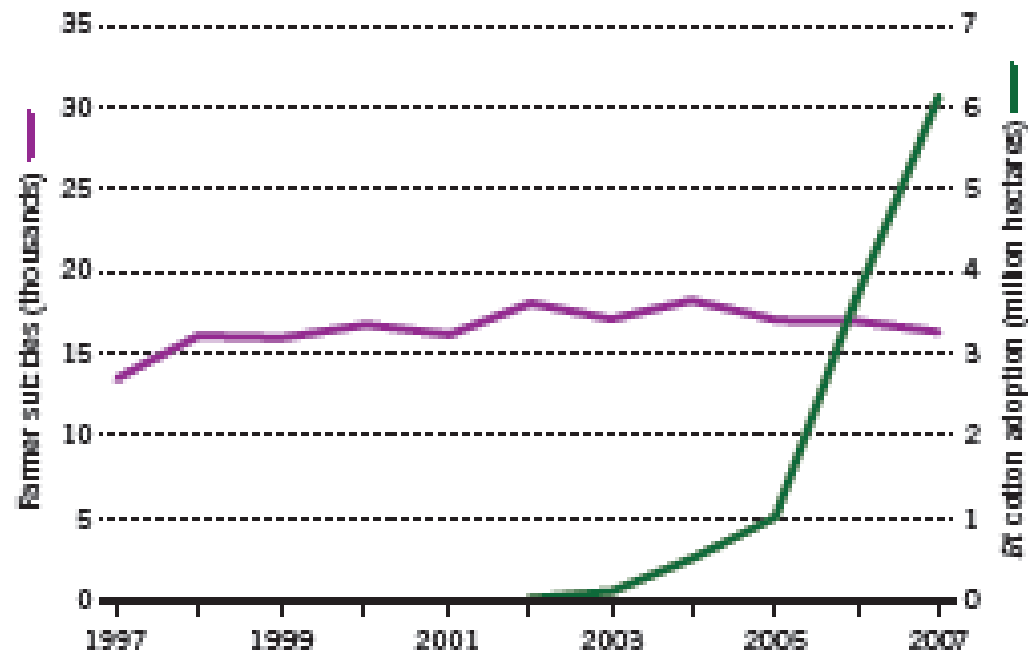
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Abundant myths, amplified in righteous books, movies, and documentaries

Farmer suicides in India and GMO cotton among the most infamous

A STEADY RATE OF TRAGEDY

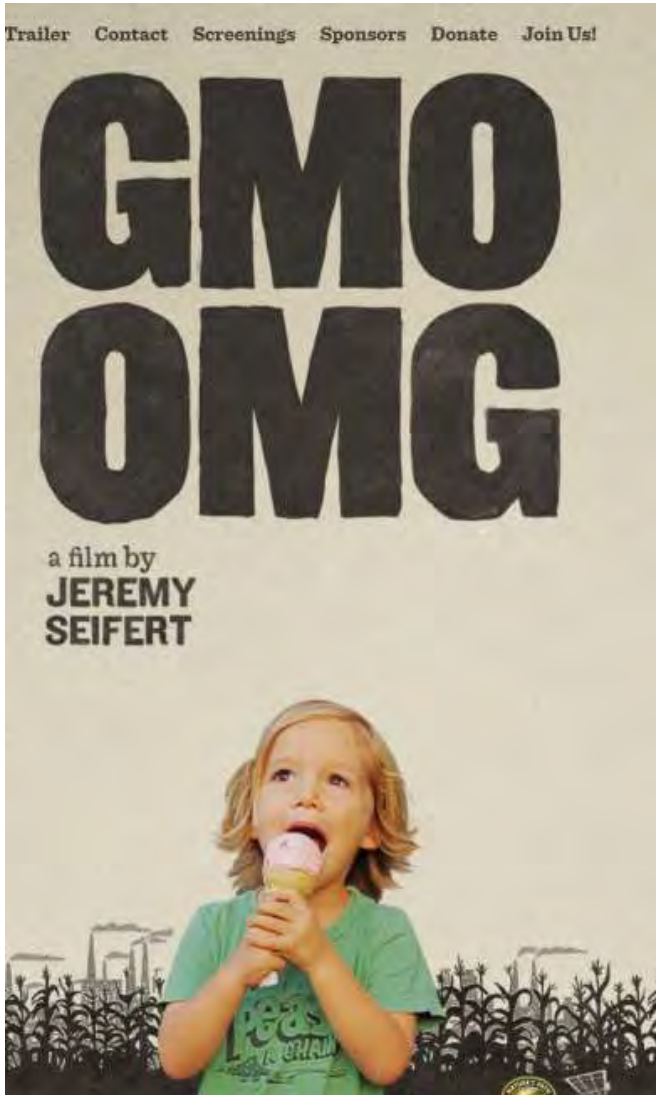
Contrary to popular myth, the introduction in 2002 of genetically modified Bt cotton is not associated with a rise in suicide rates among Indian farmers.



24 | NATURE | VOL 497 | 2 MAY 2013



“Entertaining” documentaries



IS LABELING REALLY ABOUT OUR "RIGHT TO KNOW" ?

"We are going to force them to label this food. If we have it labeled, then we can organize people not to buy it."

—Andrew Kimbrell, Executive Director, Center for Food Safety

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IS LABELING REALLY ABOUT OUR "RIGHT TO KNOW" ?

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"By labeling foods, you contribute to the suppression of consumer choices, forcing them out of the food market."

—Archie Smith, Founder, Institute for Responsible Technology

"The labeling is BS&BS. It will confuse you... For you, the label means a vital, if you get labeling, then GMs are allowed."

—Virginia Zhou, Environmental activist

"The burning question for all of us becomes: how—and how quickly—can we move beyond a system that puts profits above people's health, and the environment? In America, food is all farming? The first step is to change our labeling laws."

—Norman Coleman, Director, Organic Consumers Association

Once examined seriously, labeling does not look so appealing – serious issues include science, cost, choice, and overall ethics

“Legally mandating such a label can only serve to mislead and falsely alarm consumers”

Statement by the AAAS Board of Directors On Labeling of Genetically Modified Foods

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

20 October 2012

There are several current efforts to require labeling of foods containing products derived from genetically modified crop plants, commonly known as GM crops or GMOs. These efforts are not driven by evidence that GM foods are actually dangerous. Indeed, the science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe. Rather, these initiatives are driven by a variety

conclusion: consuming foods containing ingredients derived from GM crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques.

Civilization rests on people's ability to modify plants to make them more suitable as food, feed and fiber plants and all of these modifica-

added, the protein must be shown to be neither toxic nor allergenic. As a result and contrary to popular misconceptions, GM crops are the most extensively tested crops ever added to our food supply. There are occasional claims that feeding GM foods to animals causes aberrations ranging from digestive disorders, to sterility, tumors and premature death. Although such claims are often sensationalized and receive a

Approved by the AAAS Board of
Directors on 20 October 2012



Major newspapers agree

Tuesday, October 8, 2013 | [TRAFFIC](#) | [53%](#)

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Originally published Saturday, October 5, 2013 at 4:28 PM

Editorial: Vote No on Initiative 522, the GMO labeling initiative

Efforts to label foods with GMOs have failed in Oregon and California. Shoppers want useful information not scare tactics. Vote No on I-522.

Seattle Times Editorial

INITIATIVE 522 is a clumsy, emotion-based campaign to require labeling of selective food products containing genetically modified organisms.

The issue for proponents of I-522 seems to be less about outcomes — the products themselves — but rather finding the modern processes offensive.

Farmers and science have nurtured and bred hybrid versions of plants and animals for selective characteristics for centuries. But the efforts of the last few decades have stirred critics whose alarmist concerns are not supported by the mainstream scientific community.

Multistate efforts to require labeling of products as containing genetically modified organisms are ostensibly about a bold warning on packaging. The intent is more pointed, if a bit more subtle.

Labeling is one part of an effort to make the use of GMOs more expensive, arduous and complicated for farmers, processors, shippers, inspectors and regulators.

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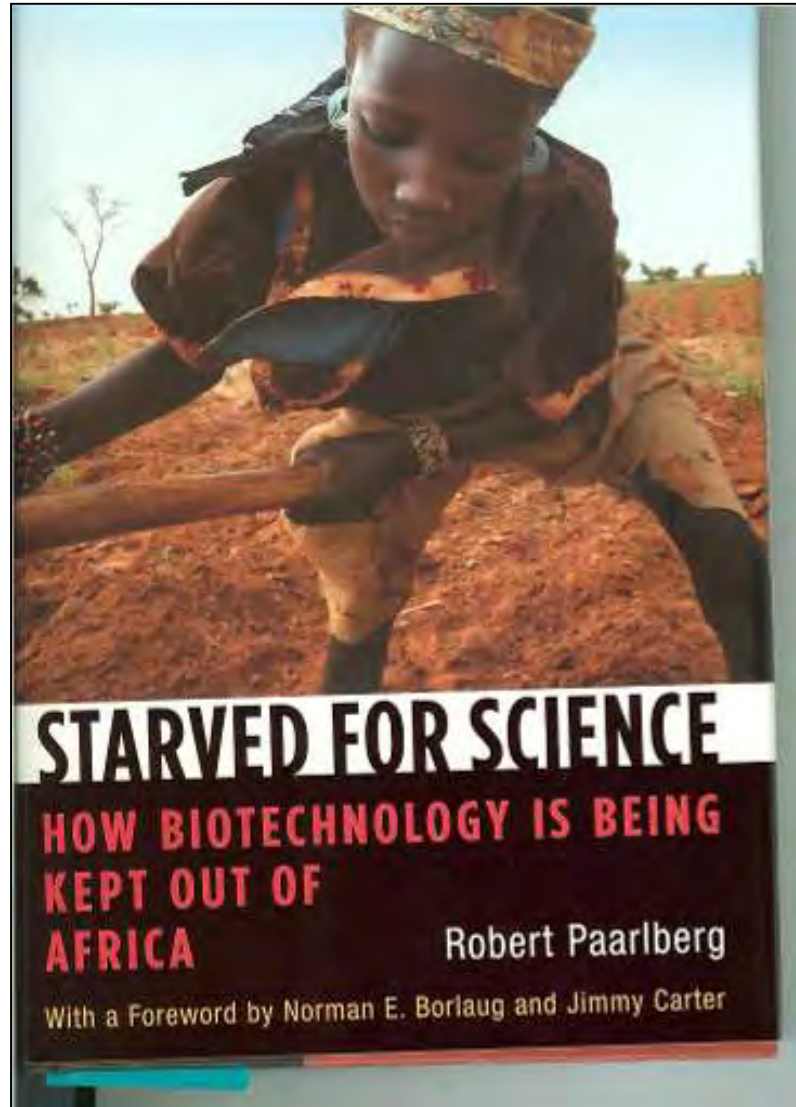
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Is it righteous to protect the developing world from GMO crops?



Golden rice and the Philippines

Vitamin A deficiency is a serious problem among the poor there. Field trials are underway to test, develop, and provide access to it for poor farmers



Intl Rice Research Inst: In the Philippines, vitamin A deficiency affects approximately 1.7 million children (15%) aged 6 months to 5 years

Subclinical vitamin A deficiency affects one out of every ten pregnant women

With funding and organization from European NGOs, field trials were vandalized in August 2013
Vandalism protested by >6,000 scientists

The New York Times

August 24, 2013

Golden Rice: Lifesaver?

By AMY HARMON

ONE bright morning this month, 400 protesters smashed c

EDITORIAL

Standing Up for GMOs

ON 8 AUGUST 2013, VANDALS DESTROYED A PHILIPPINE "GOLDEN RICE" staff of the Philippine Department of Agriculture that conduct r Global Rice Research Institute (IRRI) and the Philippine Rice Res had gathered for a peaceful dialogue. They were taken by surprise the compound, overwhelmed police and village security, and ramp uprising of farmers, the destruction was actually carried out by p night in a dozen jeeps.

The global scientific community has condemned the stunt of trials, gathering thousands of supporting signatures in a matter of a clear-cut cause for outrage, it is the concerted campaign by G governmental organizations, as well as by individuals, against G

is a strain that is genetically modified by m therefore labeled a genetically modified on duce β-carotene, a precursor of vitamin A nal component of the light-absorbing mo eye. Severe vitamin A deficiency results in t roughly half-million children who are blind. Vitamin A deficiency also compromises in exacerbating many kinds of illnesses. It is poor diet, responsible for 1.9 to 2.8 million ally, mostly of children under 5 years old an Rice is the major dietary staple for alme white rice, grains lack vitamin A. Research and Peter H



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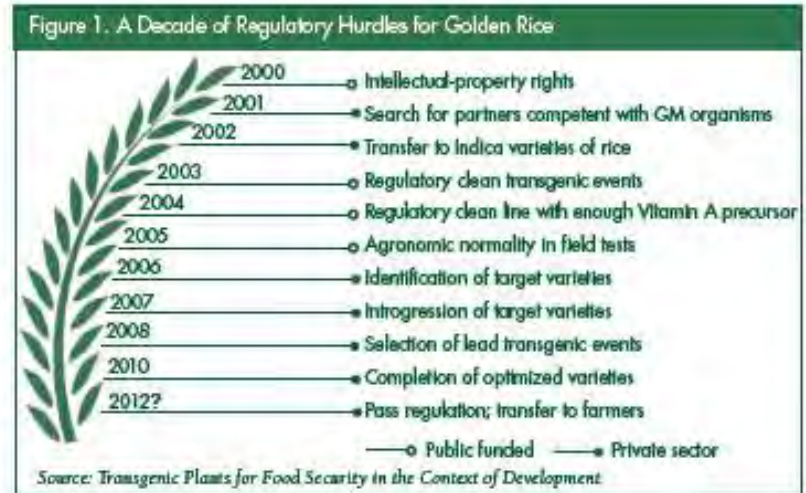
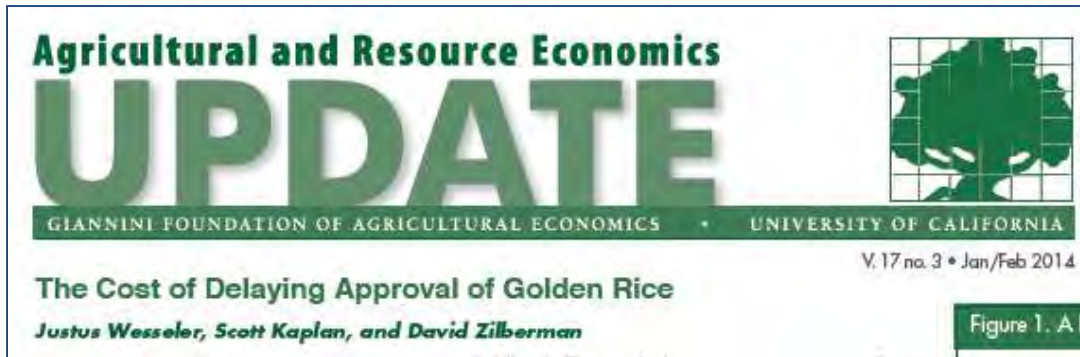
Swedish scientists decry government links to anti-GMO 'vandals'

13 Nov 2013 | 12:31 GMT | Posted by Davide Castelvecchi | Category: Biology & Biotechnology, Earth, environment & ecology, Policy

Posted on behalf of Marta Paterlini.

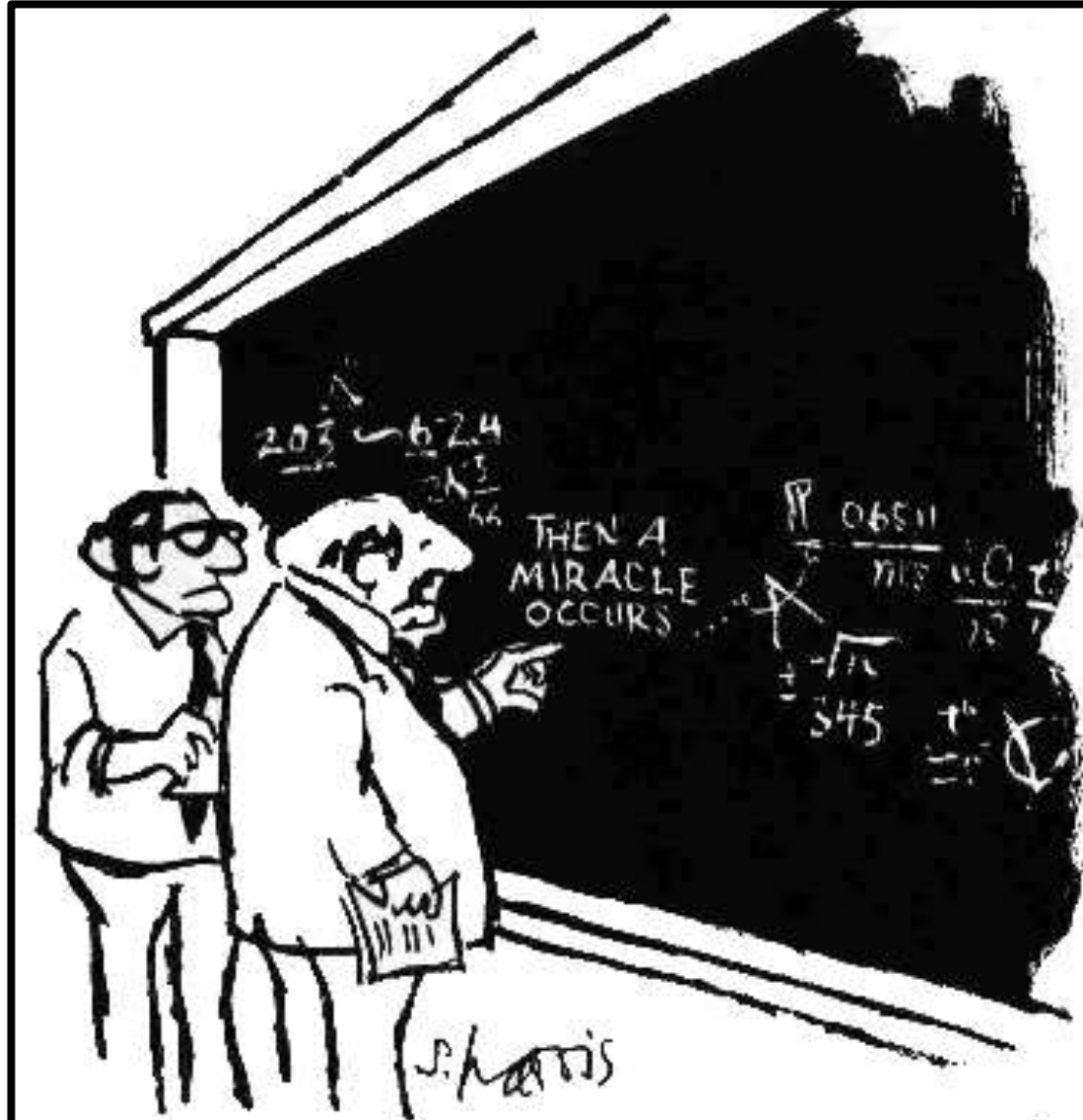
A group of Swedish scientists challenged their government in an [open letter](#) on 22 October in which they alleged that Swedish foreign aid has supported vandalism in the Philippines against research plots of genetically modified crops.

What have delays in use of Golden Rice cost? *A crime against humanity to obstruct it?*



Cost of 10 years of regulatory (political) delays

- ~\$1 billion in lost productivity
- ~1 million cases of blindness
- Several-hundred thousand deaths



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Two big narratives to choose from

- Unethical, irreversible, and unpredictable impacts on food safety and environment
 - Stop it, label it, or otherwise regulate it to where it does not matter
- Studied and regulated smartly, it is an essential tool
 - For helping people in dire need right now, and for managing a very scary future on this planet