The global debate over GMO crops
Putting the pieces together

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There are many pieces of the GMO controversy

• “It is accurate to say that many of the real ethical issues [of GMOs in agriculture] have little to do with the use of transgenic technologies” (Burkardt et al. 2005, Agricultural Ethics, CAST)
...lots and lots of pieces....

- Large vs. small-scale agriculture
- Plant variety protection
- Ecological impacts
- Food safety
- Poverty and malnutrition
- Defining precaution
- Gene flow regulation
- Benefits vs. risks of pesticides
- Intensification vs. extensification
And cognitive, emotive, aesthetic pieces

**Beauty**: GE based on understanding of nature and conscious, consultative modification

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**The global debate over GMO crops: Putting the pieces together**

Genetically modified organisms (GMOs), also called genetically engineered organisms or products of modern biotechnology, have been rapidly adopted by farmers in countries that have permitted them. However, they have also given rise to a strong and highly public global controversy over their safety, impacts, and ethics. I will try to organize and connect the many dimensions of this controversy. I will first explain what a GMO is and is not, provide an overview of their usage along with examples of current and new types of biotech crops and trees, describe what mainstream science has said about their safety and benefits, discuss the extent to which I believe that they have been debated and managed responsibly, and then finish by summarizing the moral issues surrounding their adoption and non-adoption.

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**Dr. Steve Strauss**
College of Forestry, Oregon State University

Martes 23 de Junio de 2015, 11:00 hrs.
Auditorio del Jardín Botánico del IBUNAM
Coordinadora de Seminarios: jssotuyo@ib.unam.mx
Versus these types of perceptions
Proponents of various issues frequently distort science to influence perceptions.
Money: Advocacy targeting conventional food & agriculture is large and growing

More than 500 activist organizations in North America are spending in excess of $2 billion annually engaging in food-related campaigns targeting biotech and many other elements

Jay Byrne, 2012, V-fluence
Scientists and society can differ greatly in their views on science and society.

Public and Scientists’ Views on Science and Society

Both the public and scientists value the contributions of science, but there are large differences in how each perceives science issues. Both groups agree that K-12 STEM education falls behind other nations.

88% of AAAS scientists say genetically modified foods are safe to eat; only 37% of the public agrees.

Other responses and those saying don’t know or giving no answer are not shown.
Speaking as scientist, and seeking to reflect what mainstream science is thinking and saying
Mainstream science is supportive of responsible uses of GMOs

The American Society of Plant Biologists (ASPB) supports the continued responsible use of genetic engineering (hereafter referred to as GE) as an effective tool for advancing food security and reducing the negative environmental impacts of agriculture. ASPB also supports the continued use and further development of appropriate, science-based procedures and regulations and reducing the negative environmental impacts of agriculture. ASPB also supports the

The use of GE to modify plants represents an important advance in plant science and agriculture that builds on centuries of human involvement in the genetic modification of crop species. GE

The use of GE to modify plants represents an important advance in plant science and agriculture that builds on centuries of human involvement in the genetic modification of crop species. GE allows for the transfer into a plant of well-characterized genes. The precision of this technology, coupled with the knowledge of the specific nature of the manipulated genetic information, makes the risks of unintended consequences of this type of gene transfer comparable to or less than the random mixing of genes that occurs during classical breeding (National Research Council, 2004).
Legally mandating such a label can only serve to mislead and falsely alarm consumers
Safety supported by many dozens of international science organizations

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 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.

http://www.axismundionline.com/blog/the-new-is-gm-food-safe-meme/
Foundation science
- What are and what are not GMOs?
- Use & impacts of the major GMO crops
- Fast tour of some less well known GE crops

The pieces in dispute
- Management challenges

Ethical / moral considerations
These are highly genetically modified but not GMO

Maize

Rice

Lettuce

Tomato

Banana
Many plant varieties derived from induced mutations – not GMO

- Calrose 76 semi-dwarf rice
- High oleic sunflower
- Rio Red grapefruit

Over 2,000 crop varieties derived from mutagenesis have been commercialized
Breeding continues and is accelerating in the age of massive DNA sequencing.
GMO method (genetic engineering) defined: Asexual genetic modification

Traditional plant breeding

Genetic engineering

Asexual modification or insertion from any gene source
Regeneration of biotech plants
Then propagated normally (seeds, cuttings) and tested for health and new qualities, incorporated into breeding programs.
Biotech crops widespread, rapidly adopted: Grown on >10% arable land on planet, extensive uptake in developing world

Four crops dominate, 8 crops grown in USA

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

Two traits, and stacks of them, dominate

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

- Herbicide Tolerance
- Insect Resistance (Bt)
- Herbicide Tolerance/Insect resistance

Large global benefits
2014 global “meta-analysis”

147 original studies included
“On average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%”
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

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/tod磷acts/default.asp
A few examples of new or minor biotech crop types
Stress tolerance
Drought-tolerant maize planted on >150,000 acres in USA, also being tested in Africa. Important tool given climate change, water shortages?
Many more stress tolerance, physiological innovations in the pipeline

Beating the heat

Despite the complexity of drought tolerance, researchers are making progress in the search for crops that can produce seed with limited water. Emily Waltz reports.

A revolution is quietly underway in the mid-West and Great Plains of the US. Following water shortages that have ravaged corn yields, the first of a new generation of drought-tolerant crops are being put to the test in the field. In March, Johnston, Iowa-based DuPont Pioneer announced that its newly developed transgenic corn, which downregulates production of the phytohormone ethylene, enhances grain yield after exposure to drought stress. It could join DroughtGard maize, a variety expressing a Bacillus subtilis cold-shock protein made by Monsanto of St. Louis, that has already been planted on more than 200,000 ha by thousands of farmers.

With registrations elsewhere in the world—last year, Indonesia approved a sugarcane expressing choline dehydrogenase with enhanced resistance to water deprivation—and a half-dozen other transgenic approaches to drought tolerance and water use efficiency (WUE) in testing (Table 1), biotech is making strides in bolstering crop resistance to drought. But it may not be happening fast enough. Global population increases are putting interest in drought tolerance as a trait has been on the rise over the past decade, both in industry and academia. At least 117 field trials for drought tolerance were given the green light in 2013 by US regulatory authorities alone, up from just 29 in 2004, according to data from Information Systems for Biotechnology (ISB) in Blacksburg, Virginia, a group that tracks regulatory activity. And these numbers may not include trials of drought-tolerant plants that are categorized under a more general description or an undisclosed phenotype.

Monsanto is currently conducting far more field trials of drought-tolerant crops than anyone else in the US, according to data from ISB basis to farmer states, where I Corn Belt state farmers participating planting no

<table>
<thead>
<tr>
<th>Developer</th>
<th>Crop</th>
<th>Mechanism</th>
<th>Implementation location and status</th>
<th>Field trial results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monsanto</td>
<td>Corn</td>
<td>Expresses a CASI-stress protein II from B. subtilis, which stabilizes RNA</td>
<td>Commercialized in US in 2012; summerized commercialization in US Western Great Plains and Midwest.</td>
<td>10–30% higher sugar production than conventional counterparts during drought.</td>
</tr>
<tr>
<td>PT Pohlenz-Poehnert</td>
<td>Sunflower</td>
<td>Expresses a protein from B. subtilis that stabilizes RNA</td>
<td>Commercialized in 2014</td>
<td>10–30% higher sugar production than conventional counterparts during drought.</td>
</tr>
<tr>
<td>Performance Plants</td>
<td>Sunflower</td>
<td>Expresses a protein from B. subtilis that stabilizes RNA</td>
<td>Commercialized in 2014</td>
<td>10–30% higher sugar production than conventional counterparts during drought.</td>
</tr>
<tr>
<td>DuPont Pioneer</td>
<td>Corn</td>
<td>Expresses an AGC1 RNA construct that downregulates ACG2 synthase and decreases biosynthesis of ethylene</td>
<td>Field trials in the US and Chile</td>
<td>2.7–9.3% benefit over non-transgenic varieties in drought conditions.</td>
</tr>
<tr>
<td>Aracelis Biosciences</td>
<td>Rice and corn</td>
<td>Expresses a protein that inhibits the activity of the ethylene-responsive transcription factor</td>
<td>Field trials in India and the US</td>
<td>1.5–3% yield advantage over non-transgenic varieties in drought and other stress conditions.</td>
</tr>
<tr>
<td>Verheus, a joint venture of Aracelis Biosciences and Biosyn</td>
<td>Soybean</td>
<td>Expresses a protein that inhibits the activity of the ethylene-responsive transcription factor</td>
<td>Field trials in India and the US</td>
<td>1.5–3% yield advantage over non-transgenic varieties in drought and other stress conditions.</td>
</tr>
<tr>
<td>Japanese International Research Center for Agricultural Sciences</td>
<td>Wheat, soybean, and sugarcane</td>
<td>Expresses a protein that inhibits the activity of the ethylene-responsive transcription factor</td>
<td>Field trials in collaboration with the University of Missouri and Missouri State University</td>
<td>1.5–3% yield advantage over non-transgenic varieties in drought and other stress conditions.</td>
</tr>
<tr>
<td>University of Tokyo</td>
<td>Rice and sunflower</td>
<td>Expresses a protein that inhibits the activity of the ethylene-responsive transcription factor</td>
<td>Field trials in collaboration with the University of Missouri and Missouri State University</td>
<td>1.5–3% yield advantage over non-transgenic varieties in drought and other stress conditions.</td>
</tr>
<tr>
<td>Agricultural Genetic Engineering Research Institute (EGRI)</td>
<td>Wheat</td>
<td>Expresses a protein that inhibits the activity of the ethylene-responsive transcription factor</td>
<td>Field trials in collaboration with the University of Missouri and Missouri State University</td>
<td>1.5–3% yield advantage over non-transgenic varieties in drought and other stress conditions.</td>
</tr>
<tr>
<td>Indian Agricultural Research Institute (New Delhi)</td>
<td>Tomato</td>
<td>Expresses a protein that inhibits the activity of the ethylene-responsive transcription factor</td>
<td>Field trials in collaboration with the University of Missouri and Missouri State University</td>
<td>1.5–3% yield advantage over non-transgenic varieties in drought and other stress conditions.</td>
</tr>
</tbody>
</table>
Healthier foods: High oleic acid soy oil

“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.”
“Innate” potato – Reduced browning and more – only native potato genes and modified gene expression

One hour after cutting – Control vs. Innate

Two days after cutting – Innate vs. Control
“Innate” potato – late blight resistant, reduced acrylamide, reduced sprouting and browning (↓ waste, ↑ safety, ↓ pesticide, ↑ yield)
Innate benefits

- If all USA potatoes had its improved traits, each year.
- Waste reduced by 5 billion pounds
- CO$_2$ emissions reduced by 734 million pounds
- Water use reduced by 84 billion gallons
- 2.5 million fewer pesticide acre-applications
- Marketable yields increase ~ 20%
- Growers save $240 million in production costs

Referenced analyses by Simplot Plant Sciences
Virus-resistant GM papaya
Saved the Hawaiian industry in the mid-1990s, ~70% of crop today

Like a vaccine —
“RNAi immunization” via implanting a viral gene in the papaya genome

Courtesy of Denis Gonsalves, formerly of Cornell University
Coming soon: RNAi insect pest control

The world’s most specific and safe insecticides?

Control of coleopteran insect pests through RNA interference

James A Baum, Thierry Bogaert, William Clinton, Gregory R Heck, Pascale Feldmann, Oliver Ilagan, Scott Johnson, Geert Plaetinck, Tichafo Munyikwa, Michael Pleau, Ty Vaughn & James Roberts

Commercial biotechnology solutions for controlling lepidopteran and coleopteran insect pests on crops depend on the expression of Bacillus thuringiensis insecticidal proteins, most of which permeabilize the membranes of gut epithelial cells of susceptible insects. However, insect control strategies involving a different mode of action would be valuable for managing the emergence of insect resistance. Toward this end, we demonstrate that ingestion of double-stranded (ds)RNAs supplied in an artificial diet triggers RNA interference in several coleopteran species, most notably the western corn rootworm (WCR) Diabrotica virgifera virgifera LeConte. This may result in larval stunting and mortality.

Transgenic corn plants engineered to express WCR dsRNAs show a significant reduction in WCR feeding damage in a growth chamber assay, suggesting that the RNAi pathway can be exploited to control insect pests via in planta expression of a dsRNA.

Initial bioassays, dsRNAs were applied to the surface of the WCR agar diet at concentrations from 520 ng/cm² to 780 ng/cm². As we anticipated a slower response to dsRNAs than to B. thuringiensis insecticidal proteins, the WCR bioassay incubation period was extended from 5 d to 12 d. Indeed, 7 d after infestation, little if any effect was observed. However, numerous dsRNAs exhibited significant activity 12 d after infestation, resulting in both larval stunting and mortality (Supplementary Table 1 online).

Subsequent feeding assays demonstrated that certain dsRNA samples, including dsRNAs targeting putative genes encoding vacuolar ATPase (V-ATPase) subunits A, D and E, as well as γ-2 tubulin, were active at applied concentrations well below 52 ng/cm². We identified additional WCR genes that caused mortality when targeted for suppression using dsRNAs in the WCR feeding assay. A two-tiered screen was implemented in which dsRNAs targeting different genes were tested at 52 and 5.2 ng/cm². Of the 290 dsRNAs tested, 123 showed significant (p < 0.05) larval suppression and/or stunting at 52 ng/cm². Of these, 67 showed significant mortality and/or stunting at 5.2 ng/cm².

Figure 2 F1 plants expressing a V-ATPase A dsRNA are protected from WCR feeding damage. (a) Map of the expression cassette. (b) Mean root damage ratings for eight F1 populations, the parental inbred line (negative control) and the corn rootworm–protected Cry3Bb event MON863; NIS, nodal injury score (Iowa State ranking system). (c) The plant on left is a non-transgenic control with average root damage, whereas the plant on the right shows the average root protection seen when the transgene is expressed.
Resistance transgenes promising solution/s to devastating ‘citrus greening’
Coming: Defensin-like proteins from spinach for disease resistance

Courtesy of Eric Mirkov, Texas A & M
Early flowering in eucalypts to speed breeding and research
Genetic containment - Undeveloped catkins, stable suppression of native LEAFY gene in poplar (RNAi)

Klocko et al. 2014, American Soc. For Plant Biology, Portland, Oregon

CRISPR studies in progress
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 American chestnut trees, whose hearts become so infected that they lose their ability to carry nutrients through their veins. The fungus’s spores are easily carried by wind and rain, spreading more than a mile in a single rain storm. In 1904, American chestnut seedlings were already beginning to wilt in greenhouses in the United States, but it was the second wave of attacks in the 1920s that caused the greatest losses, killing an estimated 3 billion trees.

More In This Article

A New Generation of American Chestnut Trees May Redefine America’s Forests
Diverse pipeline of biofortification products = enhancement of critical vitamins or nutrients

Many more examples funded by Gates Foundation / other sources
Summary of science

• Long history of intensive, indirect genetic modification – basis of agriculture and civilization
  • GMOs are new tools for a very old practice
• There is a very wide variety of GMO crops in the commercial and science pipelines
  • Though a few traits and crop types dominate today, if science (rather than fear) rules, GMOs will be increasingly diverse in type and benefit
• Many types of GMO crops – used responsibly – can have major economic, environmental, and humanitarian benefits
There are scientifically legitimate issues, apart from the many GMO myths and noise

All problems of Management

- Agronomics – trait management
- Ecological impacts on wild species
- Regulation – too much vs. too little
- Coexistence given diverse market streams
Poor weed management has led to rapid development of herbicide-resistant weeds and motivated development of new kinds of herbicide-tolerant crops.
Wild species impacts?
Are declines in monarch butterflies – associated with reduced milkweed populations – due to improved weed control from herbicide-tolerant crops?

Additional impacts on other pollinators?

01 APR 2012 | 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 99 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.

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 at 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 Killacky 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.
Part of larger discussion of intensification vs. extensification & ecological agriculture

We need to manage ag landscapes smarter

Why can’t selected GMOs, managed responsibly, have a significant role?
Gene flow: Genetic admixture is ubiquitous in agriculture – with or without GMOs
Global admixture of GM and non-GM crops/food create immense coexistence, trade problems under current regulations

Many costly cases of trade disruption and lawsuits with corn, soy, and rice

Oregon with major coexistence struggles due to seed industry, much non-GMO production & many exports

2014 Task Force Report
GMO ban voted on in Benton County, Oregon last month – defeated but with much public support.
No easy answers to coexistence problems

Regulations, and ultimately markets, need to evolve to enable workable thresholds for genetic admixture…

Based on science, not anti-GMO ideology, scare tactics, and trade barriers
Some ethical perspectives
Billions are malnourished now, crop land is degrading, and it’s a very scary future.
Pesticide poisoning common in developing world – eggplant, cotton examples

Climate change & travel creating urgent pest problems

This Killer Fungus Could Force the Whole World to Go Gluten-Free

Rust is depleting our bread supply, but how do we feel about genetically modified wheat?

A Race to Save the Orange by Altering Its DNA

CLEWISTON, Fla. — The call Rick Kress and every other citrus grower in Florida dreaded came while he was driving.

Field trial of Xanthomonas wilt disease-resistant bananas in East Africa

To the Editor:

Banana is a major staple crop in East Africa produced mostly by small-scale farmers. It supports over 200 million people and is the most nutritious of all the tropical crops.

The disease Xanthomonas wilt is a serious threat to banana production and has the potential to destroy entire plantations. However, the disease is difficult to control and can spread quickly.

To address this problem, researchers are conducting a field trial of Xanthomonas wilt disease-resistant bananas in East Africa. The trial involves the planting of disease-resistant banana varieties on a small scale to determine their effectiveness in controlling the disease.

These trials are expected to provide valuable information on the performance of disease-resistant banana varieties in the region and help farmers make informed decisions about the cultivation of banana crops.

Author Contributions

U.T. conceived the idea and led the study, L.S., and V.K.T. designed the study, L.U. and performed the experiments and S.K. did the data analysis. All authors contributed to the interpretation and writing of the paper.

Acknowledgements

We thank T.T. Feng, Academia Sinica, Taiwan, providing the Hsp and tPA gene constructs. African Agricultural Technology Foundation for negotiating a royalty-free license for the use of the species. This research was funded by...
Natural toxins, contaminants in food pose serious problems for millions

*Child with liver cancer in Mozambique due to consumption of mycotoxins*

- Esophageal cancer
- Neural tube defects, spina bifida
- 155,000-172,000 cases per year from aflatoxin alone

- Bt GMO corn above
- Fungal contaminated, mycotoxin-producing corn below
Billions suffer from micronutrient deficiency
Widespread, impacts severe, and decades of supplements unable to overcome

Image sources: Petaholmes based on WHO data;

Vitamin A deficiency affects one-third of children under the age of five around the world.
Is it ethical to discard this extremely powerful tool given these humanitarian crises?

Is it right for the food secure to remove it from use by the poor, or to force regulations and market conditions that effectively remove it?
Things are changing fast – We have to think and regulate differently

No-analog thinking

Novel climates, no-analog communities, and ecological surprises

John W Williams\(^2\) and Stephen T Jackson\(^2\)

No-analog communities (communities that are compositionally unlike any found today) occurred frequently in the past and will develop in the greenhouse world of the future. The well-documented no-analog plant communities of late-glacial North America are closely linked to “novel” climates also lacking modern analogs, characterized by high seasonality of temperature. In climate simulations for the Intergovernmental Panel on Climate Change A2 and B1 emission scenarios, novel climates arise by 2100 AD, primarily in tropical and subtropical regions. These future novel climates are warmer than any present climates globally, with spatially variable shifts in precipitation, and increase the risk of species reshuffling into future no-analog communities and other ecological surprises. Most ecological models are at least partially parameterized from modern observations and so may fail to accurately predict ecological responses to these novel climates. There is an urgent need to test the robustness of ecological models to climate conditions outside modern experience.

“No-analog communities (communities that are compositionally unlike any found today) occurred frequently in the past and will develop in the greenhouse world of the future.”
Is it ethical to maintain ultra-precautionary environmental regulations that presume we want to, or could, maintain the status quo?

Rapid change is upon us, the only question is what tools we are allowed to use to help manage it.
Is gene flow to wild relatives, land races, ethical?

AGRICULTURE

GM maize splits Mexico

Legal challenge to transgenic crops has created a rift in the country’s scientific community.

By Laura Vargas-Parada

The Mexican scientific community has been torn apart by a legal battle over transgenic maize (corn). Almost a year after activists challenged scientists’ right to operate a GM maize trial, the country is still divided over its potential benefits.

Maize is central to Mexican cuisine, culture and economy, but the formerly self-sufficient country now imports about one-third of its supply.
GMO maize benefits for Mexico very large – trade, rural economics and health

Maize is already a product of traditional “genetic engineering”

Gene flow is ubiquitous in maize agriculture, and an impact to some degree everywhere, GMO or not

Gene flow unlikely to reduce genetic diversity

A miniscule proportion of natural floral and fauna likely to be affected (sexually compatible, specialist)
Many options to mitigate (planting restrictions?)

Ultimate biological impacts impossible to predict, could be positive, negative, or (most likely?) negligible in degree of impact

Is GE admixture, likely at a low level, at odds with cultural values?

Are legal concerns with gene flow workable?
Two summary ethical views

Nuffield summary messages

• The use of GM crops can have considerable potential for improving agriculture and the livelihood of poor farmers in developing countries

• Assess on a case by case basis
  • No blanket acceptance or rejection of GMOs

• There is an ethical obligation to explore the potential of GM crops
ENCYCLICAL LETTER

LAUDATO SI’

OF THE HOLY FATHER

FRANCIS

ON CARE FOR OUR COMMON HOME
“It is difficult to make a general judgement about genetic modification (GM), whether vegetable or animal, medical or agricultural, since these vary greatly among themselves and call for specific considerations.”
Encyclical quotes

• “Genetic mutations, in fact, have often been, and continue to be, caused by nature itself. Nor are mutations caused by human intervention a modern phenomenon. The domestication of animals, the crossbreeding of species and other older and universally accepted practices can be mentioned as examples.”
Encyclical quotes

• “Although no conclusive proof exists that GM cereals may be harmful to human beings, and in some regions their use has brought about economic growth which has helped to resolve problems, there remain a number of significant difficulties which should not be underestimated.”
Encyclical quotes

• “A broad, responsible scientific and social debate needs to take place, one capable of considering all the available information and of calling things by their name.”
Encyclical quotes

• “It sometimes happens that complete information is not put on the table; a selection is made on the basis of particular interests, be they politico-economic or ideological. This makes it difficult to reach a balanced and prudent judgement.”
An ethic of responsible communication – at which many leaders and institutions are failing us
Four summary messages

• We intensively modify organisms all the time – the basis of civilization
• Biotech crops have had huge benefits around the globe – with much more on the way
• There is much public controversy and misinformation that clouds and distorts debate
• There are genuine issues of management, and of ethics
  • Are we using the technology where we should?
  • Are we using it wisely when we do?
• There is no question that GMOs, used responsibly, are a very powerful tool