The Logic and Consequences of Labeling Genetically Modified Organisms

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The choice facing California is not whether consumers should have information regarding consuming GMOs because non-GM food can be labeled as such, but what will be the benchmark for labeling requirements. Scientific research findings have not found GM food to be riskier to health or the environment than other foods. Furthermore, there is evidence that GM food improves both human and environmental health, increases yield and significantly reduces food prices.

GMOs (genetically modified organisms) in agriculture have been a source of controversy since their introduction in the mid-1990s. On the one hand, the planting of GM varieties has spread rapidly. In the case of soybeans, more than 70% of total acreage used for their cultivation is of some type of GM variety. However, GM varieties have not been adopted in major crops like wheat, rice, and potatoes, and are banned in the EU and most African countries. There has been continuous debate over the regulation of GM varieties, and California voters now face a proposition that will require the labeling of food that contains genetically modified ingredients.

On the surface, the main argument behind the proposition is the right of individuals to know the true makeup of the food they eat. I agree with this in principle, but in the case of this particular proposition, the crux of this issue has little to do with freedom of choice. In fact, voluntary labeling of GMO-free products can meet the informational needs of people who want to avoid GMOs. Anyone who is strongly opposed to buying GM products is free to do so, as USDA "certified organic" products do not contain GMOs.

The real issue of the proposition is the *benchmark* required for mandatory labeling. Right now, the benchmark is proven toxicity or meaningful health effects; thus, the government has rightly required the labeling of cigarettes and caloric contents. GM products are not required to be labeled because regulatory research has found them to be as safe as conventional foods. People who have additional requirements about food intake rely on voluntary labels such as "kosher" and "halal." But society does not use 'kosher' as the benchmark and require all "non-kosher" foods to be labeled as such.

From an economic perspective, labeling GMOs makes sense if the net benefit from having it outweighs the cost. While some people may feel strongly against GMOs and may vote for the proposition because their perceived benefits from labeling are very high, I suspect that there are many others who are indifferent or only slightly concerned about GM varieties, yet may be unaware of the environmental and social benefits of GMOs and the potential negative consequences of labeling. The purpose of this article is to provide research results on the benefits of GM products and some of the implications of constraining the growth and development of this technology.

On GMOs and Crop Breeding

Most of the food we eat today has been bred for humans and modified through a variety of techniques. They include traditional selective breeding, as well as induced mutations through radiation or other chemicals. The discovery of DNA and advances in modern molecular biology have allowed the development of more refined and precise crop breeding techniques where varieties are slightly modified by adding specific traits.

Obviously, GMO technologies are still in their infancy, but the cost of obtaining genomic knowledge is declining exponentially and new techniques for taking advantage of this knowledge are improving. Researchers have already discovered a wide array of genetic manipulations that can improve pest control, enhance nutritional quality, extend shelf life, and advance other aspects of crop quality and productivity.

The early commercial applications of GMOs, namely traits to control pests, are the "low hanging fruits" of research efforts and, as experience with transgenic tools is accumulated, it is likely that more appealing traits (i.e., drought tolerance, nitrogen fixation, etc.) will be developed. The application of genetic engineering techniques in agriculture has been advancing more slowly relative to that of medicine, but as we will show, even the existing traits have made an immense difference.

How Have GMOs Made a Difference?

A large body of literature has been accumulated to assess the impact of GMOs on agricultural productivity and food prices. The major applications thus far (Bt varieties or Round-up Ready varieties) reduce insect and weed damage. The impact on yield depends on whether the specific pest damage was controlled by an alternative method. In many cases, Bt varieties are replacing toxic pesticides, and the main gain is not in yield, but in improved health

Table 1. Yield, Costs, and Profitability Effects of Adopting Bt Cotton and Maize

Country	Insecticide Reduction (%)	Increase in Effective Yield (%)	Increase in Gross Margin (%)	References
Bt Cotton				
Argentina	47	33	23	Qaim & de Janvry 2003, 2005
Australia	48	0	66	Fitt,2003
China	65	24	470	Pray et al. 2002
India	41	37	135	Qaim et al. 2006, Sadashivappa & Qaim2009
Mexico	77	9	295	Traxler et al. 2003
South Africa	33	22	91	Thurtle et al. 2003, Gouse et al. 2006
United States	36	10	58	Falck-Zepeda et al. 2006, Carpenter et al. 2002
Bt Maize				
Argentina	0	9	20	Brookes & Barfoot 2005
Philippines	5	34	53	Brookes & Barfoot 2005, Yorobe & Quicoy 2006
South Africa	10	11	42	Brookes & Barfoot 2005, Gouse et al. 2006
Spain	63	6	70	Gomez-Barbero et al.2008
United States	8	5	12	Naseem & Pray 2004, Fernandez-Cornejo & Li 2005

Source: Qaim 2009.

and environmental sustainability. On the other hand, in cases where transgenic varieties address pest problems that haven't been treated before, yield tends to increase. As a rule, adoption of Bt varieties tends to have a higher yield effect in developing countries that face severe pest problems and have relatively limited access to technologies than in developed countries.

Table 1 represents outcomes of multiple studies that demonstrate this point for Bt cotton and Bt maize. The results suggest that yields may grow by more than 30% in developing countries such as India and the Philippines, while pesticide use may decrease up to 70%. Furthermore, the studies also compute that under plausible price ranges, farmer profitability per hectare is increasing and the range of gain varies across countries and crops.

One of the main concerns about GM varieties was that they mostly benefited technology providers, like Monsanto. However, GM varieties increase supply and, as a result, prices tend to decline which makes consumers better off. While farmers may have received lower prices, they also experience lower costs and higher yields. Thus, seed companies, farmers, and consumers may all share the economic benefit resulting from the adoption of GM varieties.

Several studies address the distribution of benefits from GM varieties during the early stages of the adoption of different traits in various crops from 1999 to 2005 in the United States, and the results are presented in table 2. These findings suggest that the overall gains from these early stages was very high. For example, the annual gain from adoption of herbicide tolerant soybean varieties in 1999 was between $500 million and $1.1 billion and the gain in 2001 was $1.25 billion.

In some cases, the consumer share was found to be greater than 50%, while in others, the innovator or the farmer share was very high. Altogether, the table shows that the benefits are shared among farmers, consumers, and the technology provider. Studies in other countries also confirm these results.

Studies that investigated the benefits of adoption of GMOs around the world have identified a wide variety of benefits, from increased yield and reduced cost as mentioned above, reduced financial risk associated with farming, as well as non-monetary benefits like reduced pesticide exposure for farm workers and reduced effort associated with monitoring pests and application of pesticides.

GM varieties also have significant environmental and health impacts, and a recent National Research Council (NRC) report found them to be at least as safe as conventional food. Studies from India and China suggest that adoption of Bt cotton led to a reduction in the application of pesticides and actually saved a significant number of lives of individuals who otherwise would have been exposed to toxic chemicals. Studies suggest that Bt traits in cotton reduce vulnerability to toxins that emerge in storage, and thus improve food safety.

The use of herbicide tolerant varieties led to increased use of Round-up, which the EPA considers to be low in toxicity. But at the same time, it enabled reduced tillage practices that in turn led to reductions in soil erosion, as well as runoff of water and chemicals. These GM varieties also contribute to soil carbon sequestration.

Aggregate Impacts

Most of the existing literature on the impacts of GMOs considers specific case studies and documents increasing yields, reduction in costs, and some environmental benefits. Recently, there have been attempts to assess the aggregate effects of GMOs on agricultural supplies and agricultural commodity prices.

Estimates based on aggregate data (annual national output of corn, cotton, soybeans and rapeseed, as well as acreage of GM and non-GM varieties for

Table 2. Benefits of the Adoption of Genetically Engineered Crops and Their Distribution

Study	Year	Total Benefits ($ Million)	Share of Total Benefits (%) U.S. Farmers	Innovators	U.S. Consumers	Net ROW
Bt Cotton						
Falck-Zepeda et al. 1999	1996	134	43	47	6	
Falck-Zepeda et al. 2000a	1996	240	59	26	9	6
Falck-Zepeda et al. 2000b	1997	190	43	44	7	6
Falck-Zepeda et al. 1999	1998	213	46	43	7	4
Frisvold et al. 2000	1996-98	131-164	5-6	46	33	18
U.S.-EPA 2001[a]	1996-99	16-46	NA	NA	NA	NA
Price et al. 2003	1997	210	29	35	14	22
Herbicide-Resistant Cotton						
Price et al. 2003	1997	232	4	6	57	33
Herbicide-Resistant Soybeans						
Falck-Zepeda et al. 2000b	1997-LE[b]	1,100	77	10	4	9
	1997-HE[c]	437	29	18	17	28
Moschini et al. 2000	1999	804	20	45	10	26
Price et al. 2003	1997	310	20	68	5	6
Qaim & Traxler 2005	1997	206	16[d]	49	35	NA[e]
Qaim & Traxler 2005	2001	1230	13[d]	34	53	NA[e]

NA= Not applicable
ROW= Rest of the world (includes consumers and producers
[a] Limited to U.S. farmers
[b]LE= Low elasticity; assumes a U.S. soybean supply elasticity of 0.22
[c]HE= High elasticity; assumes a U.S. soybean supply elasticity of 0.92
[d] Includes all soybean producers
[e] Included in consumers and producers
Source: NRC 2010.

different countries over time) confirmed that GM varieties tend to have higher yield increases in developing rather than developed countries. The average per acre yield increase associated with GM cotton in developing countries is above 50%, and it is above 35% for GM corn varieties. Conversely, the impacts of GM varieties on cotton and corn in developed countries are around 15%.

The impacts of GMOs on soybean yields are smaller; however, the availability of herbicide tolerant soybean varieties has contributed to a near doubling of the total acreage of soybeans globally in the last twenty years. Much of this increase can be attributed to double-cropping of soybeans with corn and wheat, so the increase in the agricultural footprint was much smaller.

The increase in agricultural production due to the introduction of GMOs has significantly affected food prices. The growing population and growing incomes in the developing world has led to increases in the demand for meats and, as a result, increased demand for feed grains. This, combined with the introduction of biofuel, led to significant pressure on food prices and the rising prices of food after 2006 had adversely affected the well-being of the poor. The food price inflation would have been even more severe without GMOs.

Biotechnology has been one of the most dominant sources of the increase in supply of agricultural commodities and thus has contributed to a reduction in agricultural commodity prices. The increase in supply of soybeans in Argentina was of the same order of magnitude as the increased consumption of soybeans in China after 2004, thereby neutralizing potential price hikes.

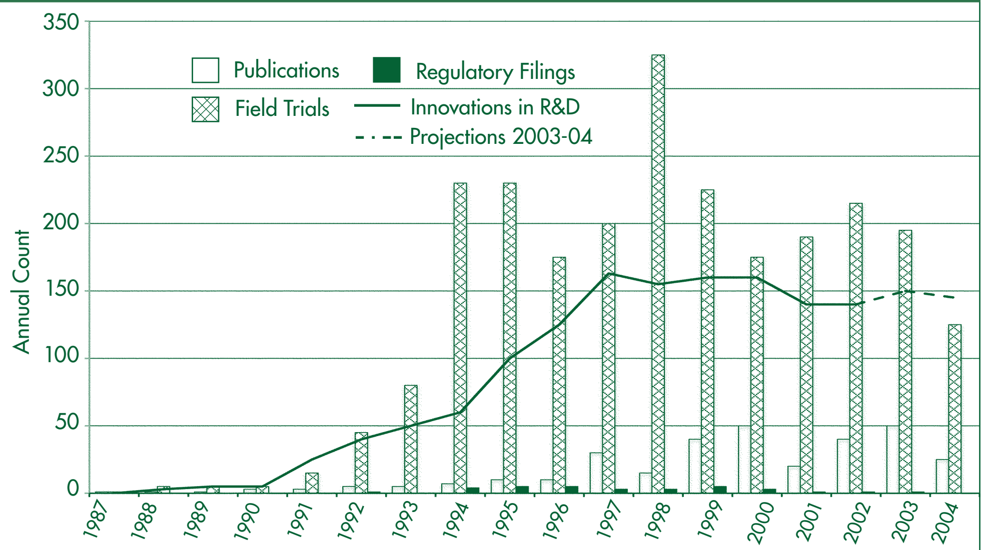
Using the same methodologies that assessed the impact of biofuel on food prices, it was found that GMOs have reduced food prices by the same order of magnitude (25% or more for corn and soybeans). Furthermore, studies suggest that if the European nations (and the African countries influenced by them) had adopted GMOs in their production of corn, soybeans and other crops, the prices of these commodities would have been substantially lower.

Moreover, existing regulations have prevented the introduction of GM varieties in the production of rice and wheat. Field studies suggest that their impact, especially in rice, can be as impressive as in corn—increasing yield and saving lives. Thus, the introduction of GM varieties to these crops would further reduce the pressure on agricultural commodity prices and improve economic well-being globally.

GMOs and the Environment

The increase in agricultural productivity and reduction in toxic pesticide use associated with GM varieties can make a difference in addressing the challenges of climate change. Higher yields mean that less land is required

Figure 1. Contractions in Agricultural Biotechnology R&D Associated with European GMO Restrictions of 1999



Source: Graff, G. et al. 2009 "The Contraction of Agbiotech Product Quality Innovation." Nature Biotechnology 27(8).

for agricultural production; thus, the increase in output due to GMOs has already contributed to reduced conversion of non-agricultural land for agricultural use, e.g., deforestation. Furthermore, through soil carbon sequestration and the reduction in use of inputs, production with GMOs has contributed to significant decreases in greenhouse gas emissions.

The ability of transgenic technologies to identify traits that can address disease and other issues suggests that these technologies can play a major role in adaptation to climate change and development of crop systems that respond to changes in weather conditions. Thus, transgenic technologies have contributed and can contribute even further to improved economic and environmental well being.

GMOs are a new technology and they have their own limitations. Obviously, pest resistance has and will continue to emerge with the use of GM varieties. The only way to sustain and improve agricultural productivity is to continue to conduct research and stay ahead of emerging challenges.

Sustainability is not a state of nirvana; rather, evolution occurs and advanced scientific knowledge and technology is the key to keeping up and improving welfare. Of course, biotechnology is one of many agricultural technologies that can play a pivotal role in our future. Integrating agricultural biotechnology with ecological farming as well as precision agriculture can lead to a much stronger and more stable system that will allow more sound utilization of agricultural resources with less environmental damages.

Many may be concerned that technological developments are frequently subject to human error, and thus reassessment and improvement of these technologies are essential. Yet, studies suggest that while there are cases of under-regulation, there are also frequent cases of over-regulation that may hamper technological change and innovation. Thus, design of efficient regimes for biotechnology is a challenge.

Conclusion

The main question is not whether consumers should have a choice regarding their own consumption of GMOs, but rather whether GM foods will be the norm and non-GM food labeled, or vice versa. Mainstream scientific research findings have not found GM food to be riskier to health or the environment than other foods. Furthermore, there is evidence that GM food improves both human and environmental well-being.

Labeling of GMOs will make GM food less attractive to some consumers, reduce demand, and make investment in this technology less appealing. We have the experience of the European ban of GM varieties in 1999, which was associated with significant contraction in investment and patenting of GM traits.

As Figure 1 shows, publications, innovations, and investment in GMOs were growing throughout the 1990s but peaked just before the ban was implemented. This has slowed advancement of the technology in an era when we need it most.

Introduction of policies that require labeling and add any other obstacles to the evolution of GMOs may have a similar effect. Voters will have to ask whether the potential gain associated with labeling is worth the cost associated with technological stagnation and the resulting losses in economic and environmental welfare.

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For further information, the author recommends:

"Impact of Genetically Engineered Crops on Farm Sustainability in the United States." *National Research Council Report* 1 (2010): 270.

Qaim, M. "The Economics of Genetically Modified Crops." *Annual Review of Resource Economics* 1(2009): 665-694.