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GM Crops and Patterns of Pesticide Use

IN THEIR REVIEW "THE ECOLOGICAL RISKS and benefits of genetically engineered plants" (*Science*'s Compass, 15 Dec., p. 2088), L. L. Wolfenbarger and P. R. Phifer provide an informative overview of a complicated set of issues. However, their discussion of changes in pesticide use includes little of the evidence available on pesticide use trends, and thus they underestimate reductions in pesticide use. In particular, the authors cite analyses of trends in corn and soybeans, but do not discuss cotton, the crop for which the most dramatic reductions in pesticide use have been observed. Further, the authors mischaracterize the need for additional studies on changes in pesticide use and the impact of these changes on the environment.

Using U.S. Department of Agriculture (USDA) data, we have analyzed changes in pesticide use since the introduction of genetically modified (GM) corn, cotton, and soybeans (*1*). Since the introduction of Bt cotton varieties with engineered insect resistance, U.S. cotton farmers have reduced the amount of insecticides used by ~2.7 million pounds (~1.2 million kilograms) per year. Corn farmers have achieved more modest reductions through the planting of insect-resistant varieties, because most growers had previously not been treating for the difficult-to-control target pest, the European corn borer. For soybean growers who have adopted herbicide-tolerant varieties, the impact has been to switch from using three or four different herbicides to using one or two, with little change in the total amount of herbicides being used.

Regarding future studies, Wolfenbarger and Phifer call for "[c]arefully designed experiments...to ascertain what effect individual transgenic crops have on agrochemical use, independent of other important variables." Although precisely measuring changes in pesticide use attributable solely to the adoption of GM crops remains a challenge, it is survey, not experimental, data that will address this question.

As for changing patterns in pesticide use, the authors are correct that this depends on the toxicity of the chemicals. However, in calling for experiments to assess toxicity, the authors appear to be unaware of the large number of studies that have been conducted on the ecological impacts of pesticides, both before and after commercialization. For example, a compendium of references on the nontarget impacts of the herbicide glyphosate lists several hundred studies (*2*). Furthermore, although the benefits of reductions in pesticide use may be clear, assessing potential benefits of substituting one chemical for another raises complex issues surrounding relative toxicity. Glyophosate has replaced the use of other herbicides in soybeans and is considered by many to be environmentally benign (*3*).

How does pesticide use change when genetically engineered crops are grown?

CREDIT: GARY GRIFFEN/EARTH SCENES

While scientists continue to debate risks such as the effect of genetically engineered corn pollen on butterfly populations, dramatic reductions in pesticide use achieved since the introduction of GM crops remain largely ignored. By focusing solely on potential ecological benefits, the authors overlook the other reasons U.S. farmers have planted GM crops on millions of acres: decreased costs, increased yields, and ease of management.

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References and Notes

1. *Agricultural Chemical Usage: Field Crops Summary* (U.S. Department of Agriculture, National Agricultural Statistics Service, Washington, DC, various years).
2. *Non-target Impacts of Herbicide Glyphosate: A Compendium of References and Abstracts* (Applied Mammal Research Institute, Summerland, British Columbia, Canada, ed. 4, 1997).
3. J. P. Giesy, S. Dobson, K. R. Solomon, *Rev. Environ. Contam. Toxicol.* **167**, 35 (2000).

Response

TWO STRAIGHTFORWARD, ALTHOUGH NOT necessarily simple, questions need to be addressed before we can understand how GM crops affect pesticide use and the subsequent ecological effects. First, what effect does adoption of GM crops have on pesticide use? For example, does use increase or decrease, or is one pesticide substituted for another? Second, how does any resulting change in pesticide use impact ecological systems? We agree that carefully designed surveys will address the first question. However, surveys are not sufficient to answer the second question.

In reviewing the literature on ecological effects of reduced pesticide use associated with GM crops, we found, but did not include in our *Science* Review, a few studies addressing pesticide use in Bt cotton. We chose instead to cite a report by USDA's Economic Research Service (ERS) that parallels the conclusions and extends the analyses of these individual studies by using a multivariate approach. Even though the USDA report represented the most comprehensive survey to date, the study might both underestimate and overestimate pesticide use associated with the adoption of GM soybeans, cotton, and corn. For example, Bt cotton targets primary pests, but increasing populations of secondary pests have been reported for Bt cotton and might require additional pesticide input (*1*). Analyses of changes in pesticide use with adoption of GM crops have focused on those insecticides that act on Bt target insects and not necessarily those used on secondary pests. Such omissions would overestimate reductions in pesticide use. The ERS analyses could also underestimate reductions in pesticide use if growers adopting Bt crops would have used an above-average amount of pesticides on conventional crops (*2*).

Carefully designed field experiments can address the impacts of changes in pesticide exposure due to GM crops on ecological systems, and it is this latter question we addressed in our Review. If researchers and analysts wish to infer ecological effects from pesticide use patterns, then the toxicity of the chemicals used needs to be incorporated into the analysis and the effect on ecosystems assessed. Although we are aware of the large amount of data, published and unpublished, available on toxicity to laboratory animals (such as mice, rats, and other model organisms) these data are not always easily translatable to effects on natural ecosystems. Large-scale comparisons among transgenic, conventional, and alternative agricultural practices provide the most direct approach to understanding the ecological risks and benefits and the variability of their magnitude.

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The views expressed in this response are those of the authors and do not necessarily reflect the views or policies of either agency or the U.S. government.

References and Notes
1. L. P. Gianessi, J. E. Carpenter, *Agricultural Biotechnology: Insect Control Benefits* (National Center for Food and Agricultural Policy, Washington, DC, 1999), available at http://www.bio.org/food&ag/ncfap/ag_bio.htm
2. G. A. Carlson, M. C. Marra, B. J. Hubbell, *Proc. Beltwide Cotton Conf.* 2, 973 (1998).

Risk Assessment Data for GM Crops

THE POTENTIAL ENVIRONMENTAL RISKS AND benefits of genetically modified (GM) crops "vary spatially, temporally, and according to the trait and cultivar modified," L. L. Wolfenbarger and P. R. Phifer emphasize in their Review (*Science*'s Compass, 15 Dec., p. 2088). The same is true for conventionally derived cultivars. Biotechnology crops are not inherently less safe than their conventional counterparts. Formal scrutiny and regulation before and after commercialization should ensure that these crops maintain their status of "as safe as" or safer than conventional crops. With the vast array of potential risks of all new cultivars, priorities must be set to identify those cultivar-trait combinations that require supplemental data to facilitate the decision-making process.

The authors focus exclusively on peer-reviewed data in the scientific literature and ignore the majority of data—that data reviewed by regulatory agencies and their independent advisors. Wolfenbarger and Phifer's suggestion as to the quantity and quality of information that should be generated not only ignores the need to set priorities but also does not acknowledge a successful history of reliance on risk assessments that use representative populations and added conservative assumptions to address uncertainties.


A target pest for GM crops, the European corn borer.

CREDIT: DONALD SPECKER/ANIMALS ANIMALS

Cooperation among a range of public and private institutions in agricultural biotechnology will be needed to fill gaps in data that are necessary to the decision-making process. Such a pact would alleviate two major constraints to progress: inadequate resources to support research, and a public lack of trust in agricultural biotechnology and those who develop and regulate it. To better deal with these issues in the public arena, an independent, multi-stakeholder, peer-review process should be created in countries where it is not already in place; where it does exist, such as in the United States and Canada, additional mechanisms to increase public understanding and awareness are needed. Our most important lesson from global discussions on new technologies is that while data alone cannot address cultural, economic, and ideological differences, we can ill afford to ignore valid data when assessing the impact of such technologies.

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Response

WE CONDUCTED A THOROUGH REVIEW OF published literature and unpublished reports on transgenic organisms in the public domain during our research, compiling between 300 to 400 freely available papers and reports. The small number of unpublished studies included in our review were chosen because they both augmented areas of research lacking extensive published data and described their methods in sufficient detail as to make them repeatable. Most of the unpublished studies we reviewed did not contain significant data or did not describe their methods in detail. However, we did not request unpublished data submitted to regulatory agencies; thus, we are unable to comment on the quality or quantity of these data. Publication of any applicable data in the scientific, peer-reviewed literature would facilitate their entrance into the public dialogue concerning the benefits and risks of GM plants.

We did identify in our *Science* Review gaps in research that will require a large quantity of high-quality data, and, admittedly, significant resources to address. Furthermore, we do not disagree that representative populations and conservative assumptions are an important component of risk assessments; however, we might differ in what we would define as an appropriate representative population. We would stress ecologically relevant populations because ecological comparisons between a GM crop and its alternatives will provide the key evidence for understanding relative environmental risks and benefits. Given the differences among ecosystems, not all ecological risk assessment data can be applied to all countries, yet we can provide a model of what data will best address these issues.

"...scientific data alone cannot address a public's concern over biotechnology."

We support Gregory *et al.*'s advocacy for science-based assessments of the potential benefits and risks of GM products and agree that scientific data alone cannot address a public's concern over biotechnology. We also believe that it is important the public is given valid, comprehensive, and understandable summaries or analyses of complex scientific issues, which is what we have attempted to provide.

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Letters to the Editor

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